TONS' HOME
ADING BOOKS

THE STORY OF THE FISHES

BASKETT

Appletons' Home Reading Books

EDITED BY

WILLIAM T. HARRIS, A. M., LL. D.

UNITED STATES COMMISSIONER OF EDUCATION

DIVISION I

NATURAL HISTORY

AMERICAN FOOD FISHES

APPLETONS' HOME READING BOOKS

THE STORY OF THE FISHES

BY

JAMES NEWTON BASKETT, M.S.

NEW YORK
D. APPLETON AND COMPANY
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G.

THIS BOOK IS AFFECTIONATELY DEDICATED TO

MAUDE HASTINGS BRUCE,

THE AUTHOR'S LITTLE CRITIC

AND KINDLY HELPER

AS HE WROTE.

INTRODUCTION TO THE HOME READING BOOK SERIES BY THE EDITOR.

THE new education takes two important directions—one of these is toward original observation, requiring the pupil to test and verify what is taught him at school by his own experiments. The information that he learns from books or hears from his teacher's lips must be assimilated by incorporating it with his own experience.

The other direction pointed out by the new education is systematic home reading. It forms a part of school extension of all kinds. The so-called "University Extension" that originated at Cambridge and Oxford has as its chief feature the aid of home reading by lectures and round-table discussions, led or conducted by experts who also lay out the course of reading. The Chautauquan movement in this country prescribes a series of excellent books and furnishes for a goodly number of its readers annual courses of lectures. The teachers' reading circles that exist in many States prescribe the books to be read, and publish some analysis, commentary, or catechism to aid the members.

Home reading, it seems, furnishes the essential basis of this great movement to extend education

beyond the school and to make self-culture a habit of life.

Looking more carefully at the difference between the two directions of the new education we can see what each accomplishes. There is first an effort to train the original powers of the individual and make him self-active, quick at observation, and free in his thinking. Next, the new education endeavors, by the reading of books and the study of the wisdom of the race, to make the child or youth a participator in the results of experience of all mankind.

These two movements may be made antagonistic by poor teaching. The book knowledge, containing as it does the precious lesson of human experience, may be so taught as to bring with it only dead rules of conduct, only dead scraps of information, and no stimulant to original thinking. Its contents may be memorized without being understood. On the other hand, the self-activity of the child may be stimulated at the expense of his social well-being—his originality may be cultivated at the expense of his rationality. If he is taught persistently to have his own way, to trust only his own senses, to cling to his own opinions heedless of the experience of his fellows, he is preparing for an unsuccessful, misanthropic career, and is likely enough to end his life in a madhouse.

It is admitted that a too exclusive study of the knowledge found in books, the knowledge which is aggregated from the experience and thought of other people, may result in loading the mind of the pupil with material which he can not use to advantage.

Some minds are so full of lumber that there is no space left to set up a workshop. The necessity of uniting both of these directions of intellectual activity in the schools is therefore obvious, but we must not, in this place, fall into the error of supposing that it is the oral instruction in school and the personal influence of the teacher alone that excites the pupil to activity. Book instruction is not always dry and theoretical. The very persons who declaim against the book, and praise in such strong terms the self-activity of the pupil and original research, are mostly persons who have received their practical impulse from reading the writings of educational reformers. Very few persons have received an impulse from personal contact with inspiring teachers compared with the number that have been aroused by reading such books as Herbert Spencer's Treatise on Education, Rousseau's Émile, Pestalozzi's Leonard and Gertrude, Francis W. Parker's Talks about Teaching, G. Stanley Hall's Pedagogical Seminary. Think in this connection, too, of the impulse to observation in natural science produced by such books as those of Hugh Miller, Faraday, Tyndall, Huxley, Agassiz, and Darwin.

The new scientific book is different from the old. The old style book of science gave dead results where the new one gives not only the results, but a minute account of the method employed in reaching those results. An insight into the method employed in discovery trains the reader into a naturalist, an historian, a sociologist. The books of the writers above named have done more to stimulate original research on the

part of their readers than all other influences combined.

It is therefore much more a matter of importance to get the right kind of book than to get a living teacher. The book which teaches results, and at the same time gives in an intelligible manner the steps of discovery and the methods employed, is a book which will stimulate the student to repeat the experiments described and get beyond them into fields of original research himself. Every one remembers the published lectures of Faraday on chemistry, which exercised a wide influence in changing the style of books on natural science, causing them to deal with method more than results, and thus train the reader's power of conducting original research. Robinson Crusoe for nearly two hundred years has aroused the spirit of adventure and prompted young men to resort to the border lands of civilization. A library of home reading should contain books that incite to self-activity and arouse the spirit of inquiry. The books should treat of methods of discovery and evolution. All nature is unified by the discovery of the law of evolution. Each and every being in the world is now explained by the process of development to which it belongs. Every fact now throws light on all the others by illustrating the process of growth in which each has its end and aim.

The Home Reading Books are to be classed as follows:

First Division. Natural history, including popular scientific treatises on plants and animals, and also de-

scriptions of geographical localities. The branch of study in the district school course which corresponds to this is geography. Travels and sojourns in distant lands; special writings which treat of this or that animal or plant, or family of animals or plants; anything that relates to organic nature or to meteorology, or descriptive astronomy may be placed in this class.

Second Division. Whatever relates to physics or natural philosophy, to the statics or dynamics of air or water or light or electricity, or to the properties of matter; whatever relates to chemistry, either organic or inorganic—books on these subjects belong to the class that relates to what is inorganic. Even the so-called organic chemistry relates to the analysis of organic bodies into their inorganic compounds.

Third Division. History, biography, and ethnology. Books relating to the lives of individuals; to the social life of the nation; to the collisions of nations in war, as well as to the aid that one nation gives to another through commerce in times of peace; books on ethnology relating to the modes of life of savage or civilized peoples; on primitive manners and customs—books on these subjects belong to the third class, relating particularly to the human will, not merely the individual will but the social will, the will of the tribe or nation; and to this third class belong also books on ethics and morals, and on forms of government and laws, and what is included under the term civics, or the duties of citizenship.

Fourth Division. The fourth class of books includes more especially literature and works that make known the beautiful in such departments as sculpture, painting, architecture and music. Literature and art show human nature in the form of feelings, emotions, and aspirations, and they show how these feelings lead over to deeds and to clear thoughts. This department of books is perhaps more important than any other in our home reading, inasmuch as it teaches a knowledge of human nature and enables us to understand the motives that lead our fellow-men to action.

Plan for Use as Supplementary Reading.

The first work of the child in the school is to learn to recognize in a printed form the words that are familiar to him by ear. These words constitute what is called the colloquial vocabulary. They are words that he has come to know from having heard them used by the members of his family and by his playmates. He uses these words himself with considerable skill, but what he knows by ear he does not yet know by sight. It will require many weeks, many months even, of constant effort at reading the printed page to bring him to the point where the sight of the written word brings up as much to his mind as the sound of the spoken word. But patience and practice will by and by make the printed word far more suggestive than the spoken word, as every scholar may testify.

In order to bring about this familiarity with the

printed word it has been found necessary to re-enforce the reading in the school by supplementary reading at home. Books of the same grade of difficulty with the reader used in school are to be provided for the pupil. They must be so interesting to him that he will read them at home, using his time before and after school, and even his holidays, for this purpose.

But this matter of familiarizing the child with the printed word is only one half of the object aimed at by the supplementary home reading. He should read that which interests him. He should read that which will increase his power in making deeper studies, and what he reads should tend to correct his habits of observation. Step by step he should be initiated into the scientific method. Too many elementary books fail to teach the scientific method because they point out in an unsystematic way only those features of the object which the untutored senses of the pupil would discover at first glance. It is not useful to tell the child to observe a piece of chalk and see that it is white, more or less friable, and that it makes a mark on a fence or a wall. Scientific observation goes immediately behind the facts which lie obvious to a superficial investigation. Above all, it directs attention to such features of the object as relate it to its environment. It directs attention to the features that have a causal influence in making the object what it is and in extending its effects to other objects. Science discovers the reciprocal action of objects one upon another.

After the child has learned how to observe what is essential in one class of objects he is in a measure fitted to observe for himself all objects that resemble this class. After he has learned how to observe the seeds of the milkweed, he is partially prepared to observe the seeds of the dandelion, the burdock, and the thistle. After he has learned how to study the history of his native country, he has acquired some ability to study the history of England and Scotland or France or Germany. In the same way the daily preparation of his reading lesson at school aids him to read a story of Dickens or Walter Scott.

The teacher of a school will know how to obtain a small sum to invest in supplementary reading. In a graded school of four hundred pupils ten books of each number are sufficient, one set of ten books to be loaned the first week to the best pupils in one of the rooms, the next week to the ten pupils next in ability. On Monday afternoon a discussion should be held over the topics of interest to the pupils who have read the book. The pupils who have not yet read the book will become interested, and await anxiously their turn for the loan of the desired volume. Another set of ten books of a higher grade may be used in the same way in a room containing more advanced pupils. The older pupils who have left school, and also the parents, should avail themselves of the opportunity to read the books brought home from school. Thus is begun that continuous education by means of the public library which is not limited to the school period, but lasts through life. W. T. HARRIS.

WASHINGTON, D. C., *Nov. 16, 1896.*

CONTENTS.

LIST OF ILLUSTRATIONS.

THE STORY OF THE FISHES.

TALK I.

What we may see on the outside of a fish to talk about; or catching a fish and examining it.

Let us suppose that in some walk we have caught a little fish out of an inland pond or brook. It is very apt to be one of the fresh-water sunfishes often known as "breams," "pumpkin-seeds" (see Fig. 1), or simply "pond-fish." It is an admirable specimen because, in all Nature, there is probably no fish that presents more perfectly the character of the class to which it belongs, all things considered.

Perhaps the first thing that we notice is its struggles as it hangs on the line or lies on the grass—an alternate wriggling, or bending first on one side and then on the other, as though it hoped to escape by this means. Since this motion is not one by which progress can be made, either in the air or on the earth, we conclude that it belongs always where we have found it—in the water.

Now that we come to think of it, the whole Form of the creature indicates the same thing—that it is intended to move through some resisting fluid, for it is shaped as a wedge at *both* ends.

FIG. 1.—Golden carp or goldfish (*Carassius auratus*), uppermost figure. Catfish or horned pout (*Amiurus nebulosus*). Fresh-water sunfish or pumpkin-seed (*Lepomis gibbosus*).

This fact means something more, for it tells us that the creature is intended not only to move but to move *rapidly*. We ourselves are made to move through the fluid which we call air, but man was never expected to cleave it as does a bird, else he would have been shaped like one, and he would have been so formed that he would go through it endwise as an arrow flies or a greyhound runs.

The gradual tapering of the bird toward the *rear* is also connected with its *swift* flight; for you will learn after a while that an object going rapidly through any medium pressing around it can make better speed because of this shape than it could if it were very blunt or square behind. But while this build aids the fishes in going quickly through the water, they are thinned off behind for another reason, more closely connected with their swimming well; the tail is their great single paddle or skull-oar which pushes their boatlike bodies along, by quick strong strokes, first on one side and then on the other, like those we saw, just now, in the struggles of the fish we have just caught.

So we shall have to say something about this part of the fish in another chapter. It is a very important and interesting topic.

This wigwag motion is in fact the only one possible for most kinds of fishes, shaped as they are, having, like the sunfish, flat sides and arched back and under parts, and great comparative depth from the highest part of their backs to the lowest parts beneath. A glance at our sunfish shows how absurd it would be

to expect such a creature to bend up and down as well as sideways. There are fish differently formed from the sunfish—as, for instance, the sea-horses—that do not bend their tails from side to side, but in the opposite direction. Most animals, in fact, that progress by skulling with their tails, as tadpoles, marine lizards, and sea-snakes, as well as fish, use the wigwag motion in swimming. It is claimed that the fish have inherited the manner in which they swim from the sea-worms that are thought to be their remote ancestors, but, however true this may be, it can not be said that it is proved to a certainty. It may well be supposed, indeed, in view of all the facts, that this way of swimming belongs to fish not only, if at all, because it was the habit of their very-great, many times great-grandparents, but because, all things considered, the fish that swim in this way could not swim quite as well in any other.

All fishes are not shaped for speed. Some do not have very thin vertical paddlelike tails, some have scarcely any tail at all, while others possess blunt heads or great, clumsy, lumplike bodies. Their entire FORMS are altered to suit the kinds of lives they lead; so that one who is learned about fish can glance at the FORM and tell you much about the HABITS and HOMES of the creature to which the form belongs, without ever having seen it before. Fishes show by their peculiar build what they *can* do just as certainly as long-winged birds, for instance, swallows, gulls, and hawks, and long-legged quadrupeds, as deer, hares, and hounds, show by their shape that they are swift; or

the tortoise and sloth show that they are slow. This little sunfish is intended for quick and sudden spurts of speed, as is a ground-haunting quail with its short, round, quickly fluttered wings; but a mackerel, a shark, or a pike (see Fig. 2) show by their build that they are all capable of greater speed, long kept up. They can swim twenty or twenty-five miles, including stoppages, per hour, for weeks. If you saw a look-

FIG. 2.—The pike (*Esox lucius*).

down which is nearly all head and no tail, a moonfish, a lump-fish with an almost shapeless body, or one of the flat-fish, a flounder, for example, fitted only for the bottom, you would know at once what a lazy life it must live. Thus FORM becomes an interesting topic in our talks.

Now let us pick up our fish. But we find it slippery with a sort of MUCUS, or slime, so that we can scarcely hold it.

Perhaps the next thing that impresses us is that this creature lies gasping in our hands as if it could not get its breath, though it is out of doors in a world full of good air; and almost while we wonder at it,

it dies. We conclude, therefore, again that it is fitted only for life in the water; and another interesting topic is presented to us, as to how fishes breathe in a place where we should so quickly drown. This will be treated under RESPIRATION.

Here, as we attempt to handle the little body, we are very impressively reminded of some spiny membranes upon it similar to that upon the tail. Our fingers in this case have been painfully pricked by them. So the topic of FINS must claim our attention, for fins are very necessary, very variable in shape and number, and very interesting members generally of a fish's make-up. Take them all around, they are about as perfect in all respects in this little fish as you will find them anywhere. They have many uses which we will discuss later. But this smarting pain in our fingers reminds us of the topic of WEAPONS also, which we shall have to remember, for even this little fellow fights with its fins and defends with them its NEST, EGGS, and YOUNG—three more new topics in a row. Wherever in this talk you see a word in small capitals, it means that you are going to hear more on that subject hereafter.

As we pass forward on the body we find on each side in front of the fins a gashlike opening by which our fish has been gasping. This may be called the gill-opening. Inside of it are a lot of interesting things called GILLS, whereby the creature breathes. We must talk of these again; for, while other animals have gills, none have anything just like these of the fishes, of which there are also many kinds (Fig. 3, on page 7).

This will introduce again the topic of RESPIRATION, and the various other organs by which a fish gets its breath.

As fishes' HEADS are adapted in shape and size to the various uses to which they are put and are more modified for the purposes than are those of many other backboned animals, they will detain us a while. Whether we human folk get our living by our hands, feet, bodies, face, delicate fingers, or general shape, our heads are only slightly changed in all the trades or professions. Those having heavy burdens on them, for instance, are only a trifle, if any, flatter than the average. But we shall find a fish's head is shaped to its speed, its position, the method of catching its prey, swallowing its food, or fighting its enemy.

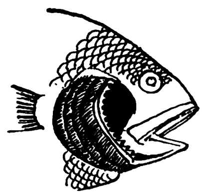

FIG. 3.—Head of fish laid open, showing position of gills.

Perhaps the MOUTH is the most formative part of a fish's head—at least the most expressive feature of its face. It ranges from the most capacious horizontal gash, almost from gill to gill, to that of a long, snipelike beak or true pipe through which the finny toper may suck up his good things as through a straw.

This leads us to the FOOD of fishes and the interesting kindred topic of FEEDING HABITS.

Before we enter the mouth figuratively, the EYE and the NOSE claim our attention and demand a joint treatment with the EAR and all the so-called SENSES,

such as SEEING, SMELLING, HEARING, TASTING, and TOUCH, and their organs.

Some fishes have special organs of touch called BARBELS, which will be noticed, but much of their TOUCHING is located purely upon the surface. The method of a fish's touching tells us a great deal of its habits.

In treating the SKIN we are necessarily attracted to the SKIN-COVERING—which is usually in the form of SCALES, as is the case with our little sunfish here. But all fish do not possess scales. Some tend to have bony plates, and even ivory as a garment; and many dress in more or less splendor at certain seasons and more plainly at others. Note the rich orange, green, and gold about our little specimen here, and you will see that another very interesting subject claims our attention—that is, COLOR and what it may often tell us.

TALK II.

Interesting things inside the fish; what it may do and how it does it.

LET us now suppose that we are at home, and wish to dress or undress our little fish, so that we may enjoy it on the table.

A great deal may be learned about the anatomy of the commoner creatures in this way, especially by boys; and little girls who expect to have homes after a while should know enough of this to direct the ofttimes-inexperienced cook about the proper preparation of game for the table. There have been some laughable and very embarrassing happenings of this kind in the early experience of young housekeepers.

As we begin to explore our fish internally, the LIPS are the first in order. We shall find, as we study the MOUTH, that these and the JAWS are quite variable in fishes.

One fish, it may be, thinks he makes himself very pretty by thrusting out his lower jaw, which at certain seasons of the year has a peculiar hook upon it. Others, as we shall see, possess great thrusting, sword-like WEAPONS formed of JAWS.

Naturally, we would associate TEETH with the jaws, but we must not suppose that we shall find them here only; for they are not only on the lips of our

specimen and many others, but on so many other queer places (even down the throat, or on the tongue, if the fish has one, which is not always the case) that it seems as if when Nature found any vacant surface in a fish's mouth she planted teeth there.

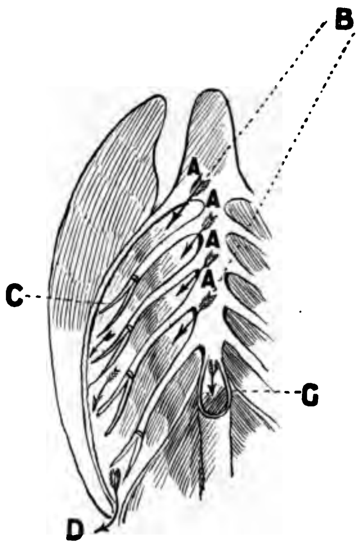

FIG. 4.—Dissection of the pharynx of a fish. Showing, by arrows *B*, the flow of the water; *A*, the gill arches; *C*, the gills; *D*, the external openings; *G*, the gullet.

Now let us take a knife and cut our fish open below, after having properly removed the SCALES and kept a few of them for later study. Notice that there is a line running down each side of the body, called the LATERAL LINE, and preserve a few scales from this also. They are different from the others.

In cutting open our fish we find how thin the wall of flesh is below, as indeed it is in all animals having a backbone; but a fish is especially thick above where the muscles are.

The first thing we note after the great cavity in the back part of the mouth, called the PHARYNX, is the tube called the swallow or GULLET (Fig. 4).

The passage to the stomach is very short and the

stomach itself often very large. Some fish throw their great stomachs over creatures bigger than themselves, almost as a fowler throws his net.

FIG. 5.—The black swallower (*Chiasmodon niger*) as it appears after swallowing a fish larger than itself.

If we rip up the region between the gills, we find the fish's HEART—always "in his throat," though he is so cool-blooded and unemotional; and back from this run tubes to carry the BLOOD, one especially noticeable just beneath the BACKBONE.

Under this tube, but still in the roof of this short

and narrow body cavity, lies one of the most interesting little contrivances in all Nature—the swim-bladder, or AIR-BLADDER, as we shall prefer to call it. It is so variable in shape and uses in different fishes that we shall have to talk of it at some length and get some artist to draw you some pictures of the different kinds. But no picture can present the beautiful pearl-like luster and light, airy structure of it which you can see here now only in the real fish.

Now if, as we eat our fish, we pull the flesh off carefully, we may study something of the arrangements of the bones. First, there are spiny or gristly spines or filaments among the fins called RAYS. These are not all alike: some are attached to the flesh only; others have other spines beneath them reaching toward the backbone, and the spiny parts of the backbone reach up toward these last. The front fins are attached to the head, and in arrangement the four lower fins are like legs.

The ribs, which are the bones that usually are the most apt to stick in your throat, lie loosely in the flesh and do not meet a breastbone below as they do in man; and they run up almost entirely to the head, so that a fish has hardly any NECK.

Finally, within the head and the hollow of the backbone lie the brain and most of the NERVOUS SYSTEM of the fish.

Occasionally, now, as we examine and eat the greater part of our little fish and compare its parts with those of others, let us turn aside to those immaterial yet equally important and more interesting

things that go to make up its life and character, and with us in our third talk form a sort of sauce to its flesh and bones. These may cause it to differ as much from others as any peculiarities of structure.

They all might be included under the great super-topic of HABITS, but we shall prefer to taste them here and there as a relish. This idea of habit means at least three things—that is, *what* a creature does, *why* it does what it does, and *how* and *when* and *where* it does it. Every creature is very largely defined by one or all of these things. It may do commonplace things, but do them in a curious manner; it may do queer things in a very uninteresting manner; or it may be curious and interesting in doing strange things in a strange way, place, or time, or with strange implements. Thus, flying is a common thing, but for a fish to fly with fins is queer indeed.

Where a creature lives, as a fish, for instance, in a general way, is called by men of science its *habitat;* but perhaps we might call this its HOME; and the exact sort of place where it lies is called the HAUNT. Thus a fish's home is in the ocean or a fresh-water river, but its haunt is under rocks or seaweed, and so on.

Our tiny fish is "at *home*" in fresh-water ponds and small streams, and its *haunt* is almost anywhere except when it builds a NEST; then it stays by that.

There are great regions where fish are very abundant, especially at certain seasons. These are called FISHERIES, and so valuable are they that nations have often gone to war over them and have made great treaties or contracts with each other about them.

TALK III.

How a fish is defined, where it gets its shape, and why it has it; or the body, head, tail, jaws, etc., as affecting form and habits.

ONLY a few minutes before the beginning of this talk the author asked a group of three young persons what each would say if some one asked, "What is a fish?" The eldest said, "I would tell him that if he was so silly as not to know what a fish is he had better go and find out." By this he perhaps meant that the inquiring person "had better go" somewhere else.

The youngest said, "I'd tell him it was a slim, slick thing that stayed in the water and hadn't any legs, and—and was a swimmer."

The third between the other two in age would say nothing, which is rather queer, since she is a girl and well-informed. She was silent, perhaps, because she knew too much, rather than too little, of the difficulty of suddenly defining a fish.

In its broadest sense, the word fish is hard to define so that every form will come under the definition, or so that it may exclude some other very fish-like creatures; but as we usually understand it, we may say:

A fish is an animal having in its flesh along the back a gristly or bony chord, and having, near its head, gills that are never shed, by which it is able to breathe in water, where it lives all its life, always having either no limbs at all (very rarely) or else (usually) limbs that are in the form of fins.

When first written, there was in the place of "gristly or bony chord" the word "backbone," which was scratched out and replaced by "spinal column." But many fish have no bones in the spinal column or spines upon the gristly chord at all, hence the use (in the place of backbone or spinal column) of the term "gristly chord," which in the lowest forms is not even scarcely gristly but softer.

All creatures having this chord, either bony or not, are called VERTEBRATES—a term it is well to remember, though it is no more correct for them all than is backbone or spinal column. In this great division of animals fishes are the lowest.

Our definition excludes, of course, whales, porpoises, and others having apparently rather finlike limbs, but breathing by lungs. A little farther away are the seals and others, wearing hair and fur, and swimming with flippers. But all these are mammals, or "beasts," to use a Biblical expression.

Much nearer the fishes are the salamanders or efts —sometimes called "water-dogs" or "mud-puppies" —all of which breathe by gills when young, and some of which may breathe thus all their lives, but when grown their limbs are true legs with distinct toes, not fins. When these are young, however, in

FIG. 6.- Sea animals that have no backbone.

the tadpole state, our definition does not cut them out. Indeed, then they are fishes, and change to the eft form as they grow.

All are capable of living on land so long as they please after they are grown, but many live much in water also.

Of course the so-called shellfish, starfish, etc., are not fish at all, since they have not even the hint of a backbone.

Fish proper have been divided into certain great and natural divisions about which it will be well for us to learn something before we talk of them, since the names of these divisions occur in all writings and talks on the subject.

The first and most perfect kind of fish is that which we most frequently see, such as perch, codfish, salmons, herrings, mackerels, etc. Our little sunfish (see Fig. 1) is a type. These all have very bony skeletons and are called in English

THE BONY FISHES.

They have only one gill opening on the outside, and it has a cover over it.

The next below these are the sturgeonlike fishes, which usually have a gristly skeleton and many other internal peculiarities which help to distinguish them, although they shade off gradually into the bony kinds and also into the next groups below them. Indeed, they are directly akin to all the other kinds of fishes, and for that reason some regard them as quite low forms. But because they are *so very strikingly* akin

to the bony fishes we must keep them next to these in our arrangement. The books call them *Ganoids*, but we will speak of them for a while as

THE STURGEON FORMS.

A little lower in some respects, a little higher in others, is a group of peculiar fishes that have lung-

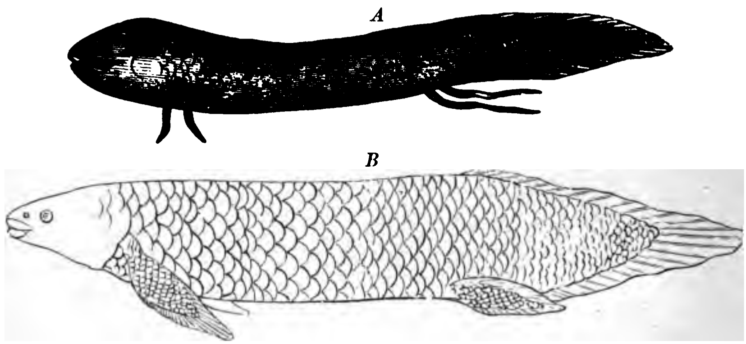

FIG. 7.—Nearest living allies of Devonian fishes. *A*, Lepidosiren; *B*, Ceratodus Fosterii. × 1/12. (After Gunther.)

like air-bladders which are useful to breathe with; and they have gills also. Besides this they have very peculiar fins that are more like legs than those of any other fishes. They are called

THE LUNGFISHES.

They also have only one gill-opening and a cover, and their skeletons are like the last group in being gristly. There are now only three living kinds of these lungfishes, and there are only a comparatively few of the sturgeon forms; but long ago these two

groups were the chief fish of the waters and among the first forms, as is shown now by their fossil remains, found in the rocks.

But there is a great group lower still, made up of the sharks, rays, and skates, which have more than one gill-opening on each side—usually five, though it may be seven in some cases. These alone serve at once to distinguish them from all other fishes proper, though there are many other very noticeable things about them that are seen when they are cut open. They also have a gristly skeleton. We shall call this great group

THE SHARK FORMS,

though all of them do not have the outward form of the usual shark, by any means, only the general structure; but that does not concern us just now.

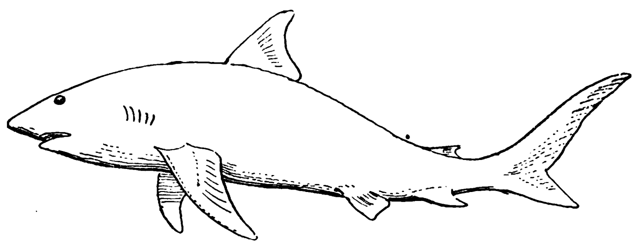

FIG. 8.—The white shark (*Carcharhinus vulgaris*).

Now these are all of the true fishes, or such as you would call fishes should you see them. Some of these even would seem very "queer fish" if you had them all before you.

But lower still are two groups that may be called

half fishes at any rate, since they do not fit well into any other of the great divisions of animals. They are hardly anything else except just themselves. To the student they are very interesting, because he thinks they tell him much of how a fish began to be, or the sort of a creature a fish was first made of; and since we shall ourselves want to refer to some of their queer habits and quaint structure, we will class them here with the rest, where their stringy backbones, perhaps in a general way, entitles them to a place.

The highest of these we will call

The Lamprey Forms.

It includes the lampreys and the hagfishes. They have a soft head upon the end of the gristly back-

Fig. 9.—Sea lamprey (*Petromyzon marinus*), upper. River lamprey (*Lampetra fluviatilis*), middle. Sand lamprey (*Petromyzon branchialis*), lower.

bone, as if a sharp stick were run into an apple. They have neither jaws nor limbs.

The next and lowest thing that has ever been called a fish by students has only a jellylike backbone, no limbs, and no head even, being so much alike at both ends that its scientific name (*Amphioxus*) means "doubly-sharp." It is in English called

THE LANCELET,

by which name we shall further speak of it. It is alone in its group, though there are below it some hints of slight kinship where the backbone may have been almost watery in consistence; but we shall not pursue the pedigree of the fishes any lower than into this headless, heartless, eyeless, earless, limbless, creature.

It is highly interesting, however, in all its lack of so much, since we feel that it must be very near akin to, or at least much like, the forefathers of all the Vertebrates.

Now let us review a little:

1. Bony fishes. 2. Sturgeon forms. 3. Lungfishes.	With gill-openings single and covered.
4. Shark forms. 5. Lamprey forms. 6. Lancelets.	With gill-openings many and uncovered.

We shall find as we go on that these groups differ from each other in many respects, and that there are other ways of grouping fishes; also that there are many subdivisions of these groups; but this is

sufficient now. The bony fishes have the largest number of kinds (species) in them, and are by long odds the most important, since nearly all our food-fishes are found in them.

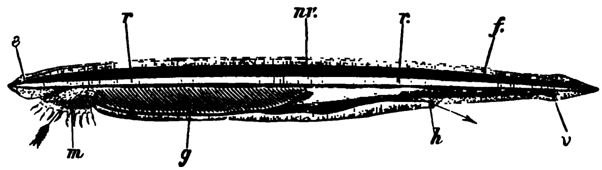

FIG. 10.—The lancelet, the lowest known fish-like form. *m*, mouth; *e*, eye-spot; *f*, fin; *r*, rod or notochord, the first faint indication of a backbone; *nr*, nerve cord; *g*, gills; *h*, hole out of which water passes from the gills; *v*, vent for refuse of food.

A fish is usually spoken of as being divided into three great parts—the head, the body, and the tail. As you can readily see, there is no real neck, although the first two joints (vertebræ) of the backbone which are next to the head are without ribs. While that part of the body just behind the head may, therefore, be bent slightly sidewise, there are only a few fishes, perhaps, that can bend their heads upward much while the body rests on a flat surface. The garpike is said to be one of these, and the limber eels can lift the head high as a snake. The pipefishes also—notably the sea-horse—seem to be able to give their necks a swanlike curve.

Our little sunfish is of that shape of body which, being deeper than wide (or thick), shows that it is not well fitted for resting on the bottom unless it lies upon its side. It is a shape that shows the fish to be a swimmer in the mid-water between the surface and

the bottom (see Fig. 1 on page 2). But some fishes that were thus shaped once seemed to have tired of this position and began lying on their sides, and thus got flatter still by the habit. Such are the flounders and others.

We can often see that the shape of the fish is in some way connected with its habits. In many cases, however, this is not so clear.

Some of the shapes now seen may be connected with habits that the fish has given up. Sometimes the same shape may have suited both the old habits and the new ones. This is the case with the flounder and his kinsfolk. Doubtless they found that by lying on one side they had not to work to keep up edgewise, and that they were thus hidden both from their foes and their prey. The latter swam near them because of this concealment, and were gulped down without pursuit. A lazy life ever after was the result.

It is a law of Nature that she makes every animal as comfortable as she can wherever it takes up its abode. It is a law of love which runs all through life that, all things considered, any material that a creature has about it is fitted as well as it can be to the surroundings, if it stays in any one place long enough.

It is well that the reader remember this, for the various parts of a fish acquire much greater interest if we look at them in this light. In these flat fishes the eye on the under side has been pulled around upon the upper, so that the creature may use them both if it is going to lie this way, and we shall find later that

FIG. 11.—Flatfish. Plaice (*Platessa glabra*), three upper fish. Four-spotted flounder or turbot (*Platessa oblonga*), fish at the left and the two buried in the sand. Spotted flounder (*Pleuronectes maculatus*), fish at lower right of illustration.

many other things have been done for this fish and others because of their special habits.

FIG. 12.—Salt-water sunfish (*Orthagoriscus mola*), background; young of same, foreground.

Perhaps about the right or normal form (that is, a form that is not distorted) for a fish is that of a herring, to mention a familiar example. Here the body is a little deeper than wide, with a beautiful, graceful taper either way. But the shape of fishes generally

ranges on each side of this. The fierasferidæ (see Fig. 18 on page 36), ribbon-fishes, etc., are mere straps and strings, and the headfish and hair-fin and others are really wider than long. The chubs, shiners, minnows, salmon, trout, perch, etc., are not far from what we may call the usual (or typical) form. Others whose forms differ strikingly from these by the peculiar shape of any parts will be noticed further on.

As a rule, if a fish appears at all flat upon the under side, no matter what its shape above, we may infer that at some time it either rests on the bottom or swims near it as a trout and our common catfish; and if it be flat on top, also, we may feel sure that it *lives* there most of the time, as the rays and flatfish noted. We shall see later that color of the body, the kind of fins and their position, and many other things, have much to tell us also of where a fish stays.

In the usual fish the body, although it may bend to a limited degree, is more or less stiff, and it can be made quite rigid; but in the eels, cusks, gunnels, and others like them, the snakelike body may be tied into knots.

To begin in the middle, there is perhaps nothing more responsible for the shape of many fishes than their stomachs. That of the shad has become typical, and is referred to as a proverb. We know what is meant at once when we liken anything, rather unrefinedly, to the outside shape of a shad's stomach. The gentle curve of the "cut-away" coat was formerly always so spoken of—a reference in the old co-

lonial days to the shape of the under side of one of their most familiar fishes.

But the stomach affects the shape not so much by its own form as by the quantity or kind of the food it has in it. Likewise the amount of eggs a fish is carrying affects its lower outline.

Fishes owe their shape in a large degree to the form and size of their heads, perhaps much more remarkably than do any other creatures. In a few

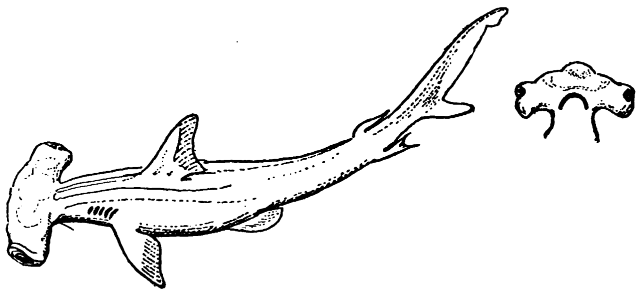

FIG. 13.—Hammerhead shark, under part of head showing mouth.

instances the head is larger than the body, and the tail seems to be attached almost directly to it. Thus in the angler or fishing-frog and its kin, and in some catfishes, the head is large and flat, with the body decreasing directly from this backward without any swell except that caused by a full stomach. Such fish can not be designed for much speed in swimming.

But in others the head is immense and almost without any tail, and apparently without any body. Such are the so-called headfishes of the sea, some of which are called sunfish, some moonfish. To prevent

confusion with our little sunfish, we shall speak of these as headfishes. Here the fish is flattened (compressed) vertically, as is our fresh-water sunfish, with the head shaped for cleaving the water, and yet having the tail, and even part of the body, apparently wanting or much shortened. Further mention of the head will come up later.

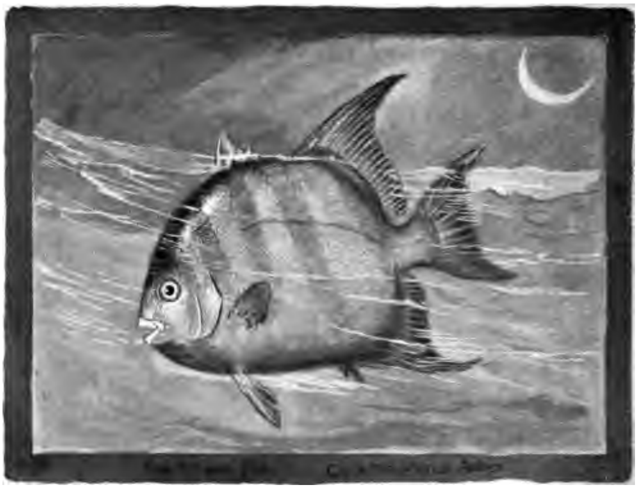

FIG. 14.—Moonfish or spadefish (*Chætodipterus faber*).

There are, of course, other objects about the head which affect the shape of the fish. In the hammerhead shark the eyes are set out on great, thick, fleshy stalks which make the head hammer-shaped and give the fish a very peculiar form (see Fig. 13, page 27).

So likewise the jaws, as in the swordfish and sawfish, extend the form of the fish far forward.

TALK IV.

How a fish is fixed for going in a straight line and for getting along in life; or the unpaired vertical fins and the tail.

ANOTHER most striking thing about a fish's figure is its fins. While in the average fish these are fastened to the body here and there as little fans, there are cases where they are greatly lengthened or expanded, and extended so far forward or around the body as to form the outer edge of the whole shape. Such is the case in the rays, flatfish, and others. In some rays even a snout is given to the fish by the fins pointing out beyond the head. In these cases the form of the body proper does not show unless the creature be turned over. More of this will appear later, when we talk of these fins as a topic.

The tail also affects the shape of the fish largely, since it terminates the body after the head begins it. It usually ends in a fin attached to it or grown around it. We may really call all that part of a fish that is behind the internal cavity its tail, but the *tail-fin* is another matter.

In our little sunfish we can see how beautifully the tail tapers off from the body (see Fig. 1 on page 2). This is the usual or normal use of it as a shaping member. In most cases the tail is flattened ver-

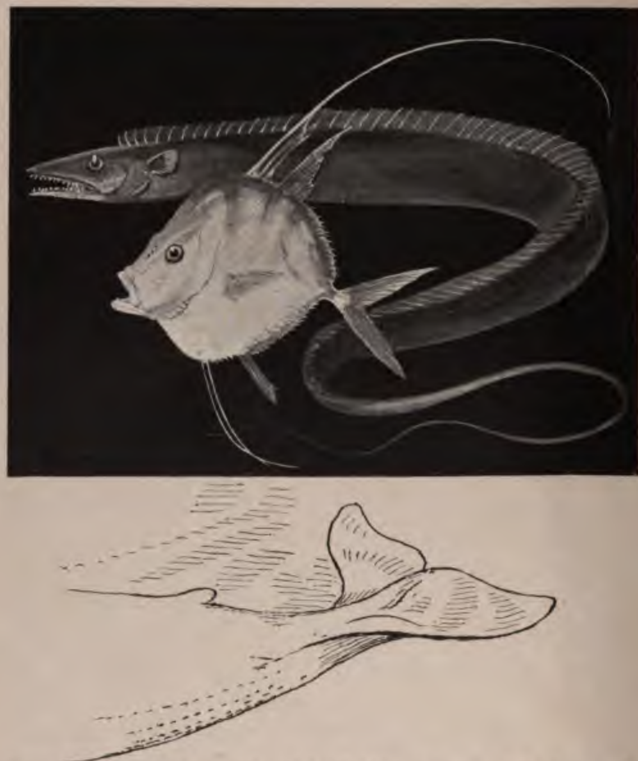

FIG. 15.—Threadfish or cutlass fish (*Trichiurus lepturus*), background. Hair-fin (*Argyreiosus capillaris*), foreground of upper illustration. Tail of sulphur-bottom whale, showing horizontal spread of tail, lower illustration.

tically—that is, up and down as a board fence stands, and not horizontally, as a plank may lie on any surface. The tails of whales and their kinsfolk are flattened horizontally, but no fish has its tail so placed

(see Fig. 15, page 30). The tails of flatfishes lie flat on the bottom and are used flatwise, but this is because, as we have seen, the fish lies and swims upon its side.

But all fishes do not have their tails flat in any way. Thus the rays and skates have a round tail, almost like that of a rat, having scarcely a hint of a fin anywhere about it. Others have them flattened, but tapered off as very long, thin, and ribbonlike, as in the eels and band-fishes, and others still have the tail thin out into a long whiplike filament, almost as if the fish were only a handle and the tail a lash. Such are the hair-tail, the cutlass fish, and some of the pipefishes (see Fig. 15, page 30). These last styles may give the fish a very snakelike appearance, as seen in the eels and others.

On the other extreme, the tail may appear as if fastened to the body by means of a stem, a hint of which is seen in our sunfish; but it comes out most gracefully in the mackerels and their relatives, where the stem is very slender. In the hair-fin it reminds one of the wasp's waist, not being one twelfth so wide as the body (see Fig. 15, page 30).

Finally, the tail, like the boy's pins which he said had saved the lives of so many persons "by they's not swallerin' 'em," can strikingly affect the shape of the fish by not being present or scarcely present, as in the headfish noted.

While we are on this topic we had as well talk of the tail's use as a fin—the great pusher or propeller. The other fins are used to move with also, but not nearly so much as the tail-fin. Really, the tail proper

is that part of the fish that lies back of the body cavity; and it is formed around the bony or gristly end of the spinal column. This latter has some interesting things about it which we shall note under BONES or SKELETON. But we often speak of the filmy fan on the end of the fish as the tail, whereas we should call it simply the tail-fin. Students say "caudal fin," which is the same thing.

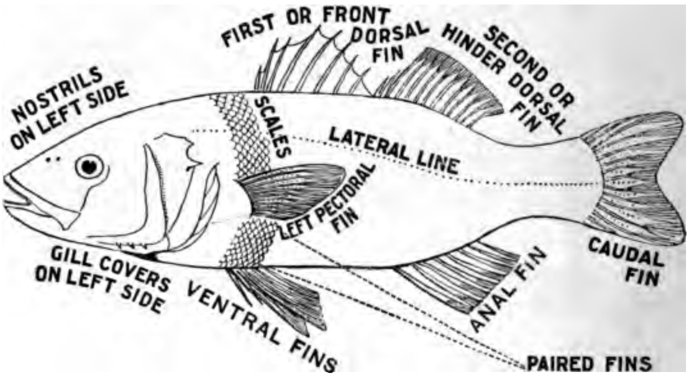

FIG. 16.—The external parts of a fish, fins, etc.

It is likely that this was the first fin that the early fishes had, since we find those very low fish-forms, lampreys and lancelets, have only a vertical filmy fringe around the rear end of their wormlike bodies.

Now let us put here the picture of a fish and learn the names of the fins, because it is very important that we should know them by name.

The tail-fin, the dorsal fin, and the anal fin are called the vertical fins because they all point vertically (directly up or down) in the middle line of the

fish. Remember that. They are also called the unpaired fins, because the next we are going to mention grow in pairs. Two of these, one on each side opposite each other, are called ventral fins. They are usually low down on the body. Those on each side are called the pectoral fins, and are nearly always up on the side somewhere near the gills.

The gill-opening is just in front of these in our cut. The gills are inside of this, under the flat gill-cover.

Now we know the outside parts of a fish so that we can talk about them. If we call the tail-fin "the caudal," the order is—in the fish here shown: caudal, anal, dorsal, ventrals, pectorals, and the gills. The dorsal is the only one on top. We shall see as we talk about them that their position and shape vary much in different fishes, as a glance again at our sunfish will show (Fig. 1, page 2). Note that the ventrals have moved forward under the pectorals. We shall talk about them all in their order.

It is to be noted that in some fishes the tail is gracefully forked and in others nicely rounded. All grades and extremes lie around and between these two forms. In the low fishes the tails are usually forked, but very seldom, if ever, evenly as in our herring. Usually, when the fin is present in the shark forms and sturgeon forms, the upper lobe is the longer. An extravagant instance is shown in the fox shark or thresher. In all fishes, as noted, the bone of the tail is bent up at the rear, though it is not very apparent in the bony fishes. The equal-shaped

tail-fin is therefore a recent and more perfected form.

As we have seen, this fin on the tail is wanting in some fishes. Thus, in order that the sting-ray and others may more forcibly strike the spines on the tail into an enemy, all hindering fringes are left off of it.

So the tail of the sea-horse is slim and capable of being twisted around seaweed, roots, etc., at the bottom, thus anchoring the creature against strong currents and tides. It has poor swimming powers, and might otherwise be easily washed away.

In general, the forking of the tail is connected with fishes that are rapid swimmers, as in the case of the herrings, mackerels, and their kinsfolk, where everything seems to indicate speed and endurance. Very often the tail-fin is square, or it may be even pointed or diamond-shaped, as in the turbot.

The tail-fin has therefore been much changed, doubtless according to the needs of the fish, but we can not always see the purpose.

Other Vertical Fins.

In their lowest form the dorsal and the anal (fins) are very closely connected with the tail-fin. As we have seen, they perhaps grow with it as one continuous fringe around the whole rear part of the fish. In very little fish just hatching they are joined to it for a while, and only later break up into separate fins. We shall see, further on, that this hints that at an early period of the fishes' history the fins were this way all the time, as they are yet in the low forms. They be-

gan likely (we learn in the same way from the hatching fish) as mere folds of the skin, and did not have any little gristly threads (rays) or bony pins (spines) in them, as we see in those of the sunfish and others

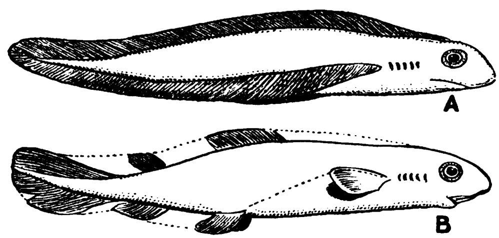

FIG. 17.—The origin of fins. *A*, showing the unborn fish, and probably its first state, with one unbroken and continuous fin; *B*, showing the two dorsals, the caudal and anal unpaired fins, and the pectoral and pelvic paired fins. (After Weidersheim.)

now. They are found so yet in some very low forms known as the fringe-finned fishes.

These vertical or unpaired fins are very interesting because of their great variation in size, extent along the body, and their many divisions and peculiar shapes and uses. They are very helpful in describing a fish and in distinguishing some groups or families.

They may be of nearly the same length, as in our sunfish, and almost opposite each other, or they may differ in both length and position, as in the herring. They may, as here, also be far forward from the tail, or merged almost into it, as in the turbot, and entirely into it in others. In the turbot, the sand cusk, and other flatfishes they tend to run almost all around the body.

To begin with the dorsal, it may run the whole length from head to tail, as in the sand cusk, or it may be short and of only a few rays, as in the catfish (see Fig. 1), or it may be absent altogether. It is often formed into two separate or at least very different parts, frequently into three, as in the codfish family, and occasionally it may have a host of little divisions near the tail, as in the mackerel family. In this case they have rays in them and are called *finlets;* but in the salmon forms, catfish family, and others there may be a single little fin without rays, formed mostly of fat. They are called "fat-fins."

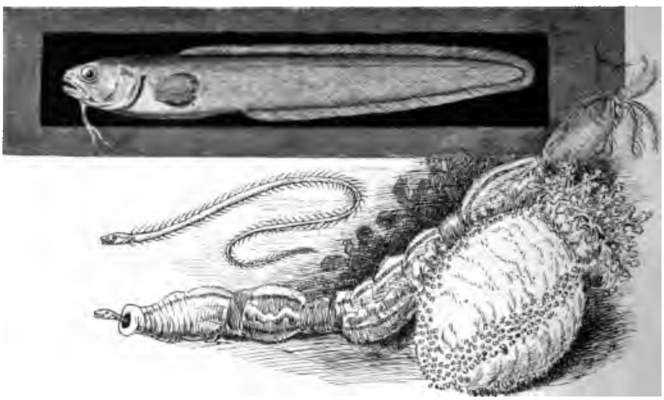

FIG. 18.—The sand cusk (*Ophidium marginatum*), upper. Fierasferidæ (*Enchelioplus tenuis*); a fish is shown with head projecting from the sea-cucumber or holothurian, inside of which these fishes live.

But the most important division of this dorsal fin is that, in the highest fishes, the forward part tends to have its rays changed into hard bony spines, while

the rear part may remain soft-rayed. These two parts may be widely separated, as in the mullets (see Fig. 19, page 37), or join each other, as in the sunfish, or

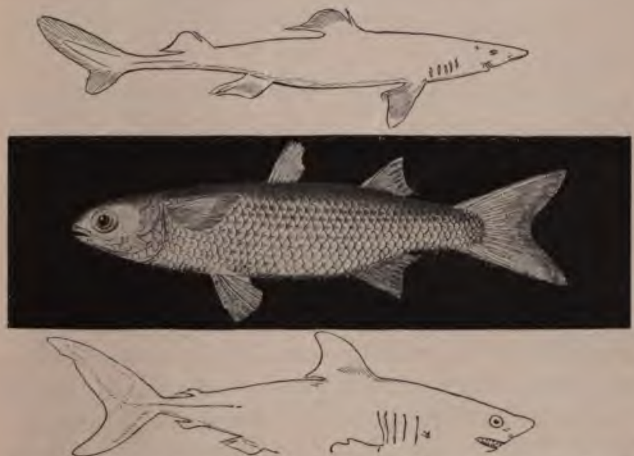

FIG. 19.—Horned dogfish (*Squalus acanthias*), showing spine on dorsal fin, upper. The mullet (*Mugil brasiliensis*), middle. Mackerel shark (*Lamna cornubica*), showing unequal lobes of tail, lower.

the whole dorsal may rarely be spiny. Sometimes the film is wanting in front, and the spines exist alone, as in some sticklebacks.

Another very peculiar change is that of making a sucking disk out of the spiny part of the dorsal, whereby the remora clings to sharks and others and gets a free ride all the time.

The anal fin also tends, in the higher groups, to be wholly or partially spiny. As in the other case, it is always in the forward part that the spines are thick-

est and strongest. Many low fishes also tend to have one or two spines on the forward edge of the fins. This is especially the case in the dorsal fins of the sharks, where one or two of the great spines are usually so noticeable as the fish approaches (see Fig. 19, page 37).

The anal often extends far forward also, but not so far as the dorsal. It is always limited by the body cavity. In many fishes, as the bluefish, the two appear equal, making a pretty appearance. In the headfishes this is especially noticeable (see moonfish, Fig. 14, on page 28).

Likewise the anal may be divided into more than one portion, and have finlets behind it, as in the mackerels. If small, it is usually farther back than the dorsal, and it is often smaller and more frequently wanting. Rarely, as in the European bream, is it larger (Fig. 90, page 235).

TALK V.

How a fish poses and keeps its head and back up; or the paired fins and their uses, location, etc.

WE now come to the paired fins. We will note again that those two which are either far back or low down are called ventrals, while the pair that is always far forward and usually well up on the sides near the head are called pectorals. When the pectorals and ventrals are very near each other, the latter are always the lower. These four fins stand in the places of the limbs of the "four-footed beasts"—that is, they correspond to or represent them. The fish, however, uses them to swim with usually, though, as we shall see, there are a few that really walk by their aid. No parts of the creature are more readily changed in shape or shifted in location upon the body to suit the demands of habit than are these. This is especially true of the ventrals, which are really the hind legs. In all the low fishes—shark forms, sturgeon forms, and lungfishes—these are found far back on the body, and in the lowest of the bony fishes they are thus placed; but they gradually move forward, as a rule, as the fishes appear higher in the scale. They never pass behind the body cavity, but may go forward to the throat, even getting in front of the pectorals as

in the great weever. In this case the length of the anal seems to have crowded them forward, for they are never found behind this, since it is always *behind* the rear opening of the body cavity, which may sometimes be under the throat also.

In many fishes the ventrals are quite small, even when the others are large, and they are perhaps more frequently absent than any others. This is especially apt to be the case with all the eel-shaped or long snake-like fishes that wiggle in the mud, and with many others that lie on the bottom where these fins would probably be in the way. In some that float stomach upward they are also gone—perhaps because they are useless. But in some others, as the swordfish, which swim in mid-water, we can not see why they are now absent.

In other cases, as the codfish family, the ventrals, usually when far forward, are reduced to a few rays, perhaps only one. These then become stringlike and act only as "feelers." In this case also the fish is apt to be a bottom-feeder. A remarkable example is the forkbeard, where they are usually lengthened (Fig. 37).

Perhaps one of the most peculiar uses of the ventrals is that of being situated close together on the under side near the tail, as in the gobies, and forming a sort of sucking disk by which the fish clings to rocks when it wishes to be quiet. Sometimes when far forward the whole shape seems changed into something much like that of a foot or clinging or grasping member, as in the little mousefish, which thus crawls among floating seaweed to hide (Fig. 38).

When they are behind the gills, these fins are attached to the flesh only, but when farther forward they may have a bony connection with the head.

Pectorals correspond to the forelegs of beasts, but in nearly all cases they are well up—always rather on the sides of the body. In most cases they are behind the gills; but in that curious section which contains the batfishes, frogfishes, and anglers, the gill-openings seem to have crept backward, and they open behind the fin as if in the hollow of the arm. Some pectorals, however, are low enough down to act as props to keep the (rather round-bottomed) fish upright when it wishes to lie on the bottom of a stream a while to watch for prey. This is the case with the salmon, trouts, etc., where the ventrals are likewise well spread apart and usually far back. In perhaps all cases where the ventrals are far forward the pectorals are well up, and in few cases are these kinds of fishes bottom-haunters; but if they are such, the ventrals, as in the codfishes, act merely as feelers.

To show how hard it is to hold Nature down to a fast and fixed rule, we will notice that in some instances the ventrals remain large and the pectorals have about three of their front rays separated entirely from the rest of the fin and converted into feelers, which appear much like the feet of insects. With these they seem to crawl or pull themselves along on or near the bottom, while the body appears perfectly poised in the water. It is known that such fish are really feeling their way along rather than crawling. Almost any public aquarium has in it an

FIG. 20.—Sea-robin (*Prionotus lineatus*), central picture. Climbing perch (*Anabas scandens*), lower figure. The illustration in the background shows the climbing fish ascending a palm tree.

example of the beautiful sea-robin which may be frequently seen thus feeling the bottom (see Fig. 20, page 42).

In the frogfishes and their kin these fins appear to be fastened to the body by a kind of stem, especially noticeable in the batfish; the fish crawls about with them (see Fig. 23, page 47). In many cases, where the pectorals are of the usual shape, they may

FIG. 21.—Mud skippers (*Periophthalmus koelreuteri*).

be stiff and spiny and project downward so that the fish may not only walk clumsily by them, but actually leap on dry land and escape threatened danger by their aid. Such is the case in the mud skippers (see Fig. 21) and in the climbing perch, which latter is said to climb trees by the aid of these and the similarly spiny ventrals (see Fig. 20, page 42).

On the other hand, the pectorals may point rather upward. The reason for this can not always be known unless a close study of the habits are made; but in the flying fish this, combined with their pointed shape and great size, fits them to act as do kites, to bear the fish along for a time. Here they are like the wings of some insects, and are set much as those of a hawk when they are partially closed in the act of darting down on prey. In these cases the long tips of the fins reach almost to the tail. These pectoral fins are the longest, in comparison with the length of the body, of any known (see Fig. 25, page 49).

The pectorals are widest, and extend farthest forward in the rays, and skates, and angel fish, where they flatten out and are carried up over the whole body as a sort of fleshy or leathery cloak or cover; and they are spread away out—really giving the entire shape to the fish as viewed from above—even beyond its head (see Fig. 26, page 51).

From these unusual sizes and forms, the pectorals run down to a few rays, making a very narrow fin. Usually the shape is that of a rounded fan, or it may be pointed—in a few cases forked a little. Large pectorals do not seem associated with speed, since on the swiftest swimmers, as mackerels, herring, salmon, etc., they are very small, and are folded back against the body when the fish is going fast. After the tail fin, the pectorals are the most important. If a fish begins to lose fins from any cause, these are the last to go—except the tail-fin—as we may see in eels and other rather degraded forms. In no true

fish are they wholly wanting perhaps, but in the lampreys and hagfishes they are either lost or have never grown.

The tail-fin is the great pusher or propeller, acting as a single sculling oar. It has the rays which support the filmy part so attached that they may bend back as the tail swings around forward, but be held stiffly, resisting as the strong stroke is made the other way. The wiggling which is a part of these strokes helps also to push the fish forward. Snakes swim fairly well without any flattened tail or fringe at all.

Of course, especially in slow movements, the paired fins help, and in the head fish, where the tail is nearly gone, and in those where it is not fringed at all, these fins do the work when they are present. This is the case in the rays. Here these fins move much as the wings of a bat, but usually in the other fishes they are flapped more directly backward. At times their motion is very rapid.

But these fins are used more in turning, stopping, and elevating the body—especially the front end of it—than they are in propelling. In a similar way the ventrals may be used.

Besides the tail-fin, the other two vertical fins—the dorsal and anal—may aid a little in pushing. Indeed, in many fishes they are so far to the rear that they may be moved with the tail as it moves its own fringe.. But aside from this they are known (in very slow-moving fishes) to help push by a peculiar wavy motion of the edges, beginning at the front and running back (see Fig. 22, page 46).

You can see that as the curve C, beginning at A, moves backward to B, it tends to push against the water, and thrust the fish forward to the left. In the flat fishes these fins act in this way partly, but the tail helps also. In the little sea horse, however, this is the chief method of moving along, together

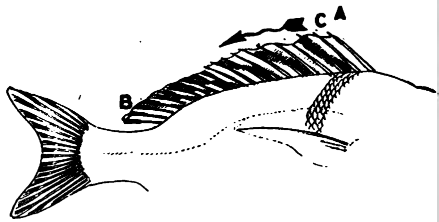

FIG. 22.—The motions of the dorsal fin.

with a little flapping of the pectorals (see Fig. 24, page 48). As these little fishes pass each other they sometimes reach out and link their slim, curling tails together in a sort of greeting, not unlike our hand-shake. The tail is thus reserved for anchoring and social purposes solely.

The thin edges of the pectoral fins, also the rays, help them along in this waving way. Likewise these waves may at times be seen running up and down the straight edges of the tail-fin in some ordinary fishes, when they desire only a slight motion.

But the chief use in all fins, except that on the tail or those moved by it, is to poise or balance the body properly and to direct or guide it. Thus the solid and heavier parts containing most of the muscles being so near the top, the back of a deep-bodied fish

FIG. 23.—Batfish (*Malthe*).

tends to turn it over on its side, but the paired fins prevent this; and when the tail is making great lashes for speed the body tends to wigwag, and this is resisted by the dorsal and ventral. They act very much as do the feathers upon an arrow.

It is said that the cruel experiment has been tried of cutting off the body-fins. If the paired fins are

FIG. 24.—American sea horse (*Hippocampus hudsonius*). Young escaping from the pouch of male, lower figure. Australian sea horse (*Phyllopteryx eques*), upper illustration.

both cut off on one side the fish falls over in the opposite direction. If all are cut off it floats as a dead fish, being unable to go under the water. If only the dorsal and anal are removed it swims in zig-

zag. If the pectorals be cut off the head hangs down and the fish can not swim to the surface.

A fish whose ventrals are set far back may get along fairly well without them; but when they are far forward under a large head and (what appears as) heavy shoulders, as in our sunfish and others, they as well as the pectorals would, if absent, be much missed. It is likely that they are set thus forward, in some cases, to aid the pectorals in helping a fish to hold up its head.

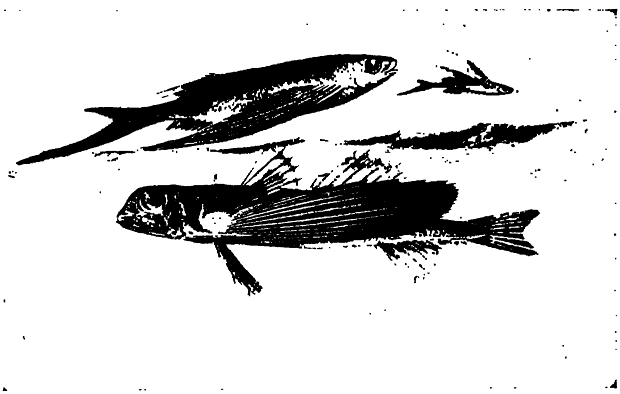

FIG. 25.—Flying fish (*Exocœtus volitans*), upper. Flying gurnards (*Dactylopterus volitans*), lower.

The position of the ventrals well forward seems to be associated often with the presence of strong sharp spines in the front part of the dorsal fin. Since these dorsal spines are used as weapons, as one fish darts under the other, the ventrals may be so placed that they may aid the pectorals in bearing upward forcibly, so as to saw harder on the enemy's thin and tender under parts.

TALK VI.

How a fish uses threads and needles, and may wear patchwork as a garment and armor; or rays, spines, scales, and skin.

WHILE we have spoken of the shape, location, and uses of the fins, we have neglected their structure and growth. In the usual fin we find either soft, threadlike little gristles running through them, or else there are bony spines or needles supporting them. The first of these are called rays, and the second spines.

It is not hard to see that a spine is a ray that has *become* bony. From this we are inclined to feel that rays were formed first, and that *later* spines were made from them. Naturalists say that fins were at first mere folds of skin, and that these little threadlike rays have grown into them later. We find this is the case as a *little* fish grows. It has at first folds, then soft rays, which afterward harden into spines.

While away down in the rocks the fossil fishes which have spines (as well as rays) in their fins are of a very early type, we find now that in the bony fishes the spiny-finned kinds are the highest, and, from other things, they appear to be evidently the latest formed.

Thus the bony fishes (which include most of the fishes) seem to be split up into two sections over the subject of this needle-and-thread business.

There are, however, some families that have both kinds of fins, or rather fins with both spiny and soft

FIG. 26.—Angel fish (*Rhina squatina*).

rays in them. They thus form connecting links between the two great groups. So extensive is this intergrading that the rays and spines alone are not enough to separate the two divisions.

But these bony fishes differ in many other things

that show a family rupture away down the ages somewhere. The soft-finned branch tended to wear its air-bladder with a tube attached to the stomach, and to fasten its ventrals far back and to pin on its pectorals rather low down. It rarely had any spines in the ventrals.

The other and higher branch had some spines in all the fins, often quite abundant, wore a ductless air-bladder or none at all, fastened its ventrals far forward and its pectorals high up on the sides, and had some other peculiar and rather modern arrangements of parts.

In the lower division, or soft-rayed fishes, the rays appear to be broken up into a series of little sections or joints, whereby they are very easily bent (flexible); and some are even branched out near the tips into many spreading twigs or forks. Although a few of the rays in these fishes (always those in the *front* end of the fin, as we learned in the study of the dorsal) often harden into spines, those persons who have looked say that, with a microscope, the original little sections can still be seen—now fused together. In the spiny-rayed fishes the spines, it is said, do not show these joints under the glass.

We shall see that Nature is very prone to put a bone or bony matter anywhere that it seems to be needed, and she may build bones out of gristle or directly from the flesh and the skin.

All rays are formed from the skin, and it might be more correct perhaps to say that when soft they tend to be horny rather than gristly. The film that

is supported or stretched between them is a sort of very thin skin.

This bone-forming tendency in the fins is shown also in the very low fishes which are below the bony kinds. The sharks have, in some cases, one great spine in the front edge of the dorsal (see Dog Fish,

Fig. 27.—John Doree (*Zeus faber*).

Fig. 19, page 37). The preservation of this fin along with the teeth in the very old rocks helps to identify a fish that had no really bony skeleton to leave behind it, and it shows us how these early spines began to form.

On the other hand, the soft rays have sometimes been "long-drawn-out" for ornamental and protective purposes, as seen in the hair-fin, and in the John Doree and the young angler (see Fig. 27, page 53; also Fig. 28). We have also noticed in the sea-robin that these may be separated and shaped into feelers, etc.—a use which will be further noticed under TOUCH.

The spines of the fins are often capable of lying back upon each other, and can be erected at will so as to give a very terrifying or frightful appearance. We shall see later, under WEAPONS, that they may be useful as well as frightful, and that a fish may literally almost look daggers at his enemy.

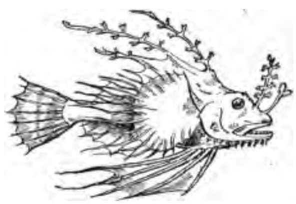

FIG. 28.—Young of goosefish or angler.

Some of these spines have behind them deep grooves in the flesh, into which they may shut as the blade of a knife into its handle—so that the fish may be guilty of really carrying concealed weapons. Many spines are fastened simply to a little bony base that sits in the flesh, and, in a few cases, the joint is the same as if a ring were set in a staple—just as two links of a chain join. In this case the spine has a hole or eye in the lower end, and is really a bony needle; and this kind and others have really been used as a needle by savage peoples. Perhaps the needle had its origin thus: for in many cases, where man

has called himself an inventor, he has been merely copying Nature. In this respect he owes no class of creatures more than the fishes, and really seems to owe them a royalty on his boats, paddles, screw propellers even, rudders, keels, and so on. It is only lately that we found out that a yacht with a center-board could outsail one without it; while the anal fin of the fish was acting as such in ancient seas, the only hint of man was—a jelly string.

Rays can not in any sense be called a fish's fingers, since they are more truly merely nails or claws. They are capable of being regrown at the tips when worn or broken, as are also the films between; but the higher fishes can not regrow any other lost parts.

Scales and the Outside Skeleton.

Before she made the true fishes and the few fish-like creatures, Nature had been putting nearly all of the skeleton on the outside of things. Now and then she placed a soft bone somewhere inside, like that of the cuttlefish on which we feed canaries; but it did not seem to mean much. Often this outside skeleton was stiff or unjointed, as the shells of the mollusks; but it was also frequently hinged and flexible, like the armor of the old knights, as we may see in the lobsters and insects.

When she put an inside skeleton in things, Nature did not quit this old way of building from the skin these outside horny or bony coverings wherever they were still needed, but she did not hesitate to tear them off when they were much in the way or of no use.

Many fishes now do not have this outside hard covering, which consists usually of scales or bony plates, but the evidence is that all true fishes have had it in some shape, and that those which appear naked have lost it.

Thus in some smooth fishes there are said to be small scales, which scarcely touch each other, lying hidden beneath the skin. Such is the case usually in the trouts. The lampreys, most eels, and many higher fishes, are entirely naked. Some of these may never have had any scales, since the lancelet—hinting so much of a fish, and yet so near the worms—has none.

The true scales of fishes seem usually to consist of horny material, somewhat like that of our finger-nails, though in some cases they become bony, or are in the form of bony plates. They seem to be easily developed on any surface where there is need for them. Thus, on the human heel—especially when much exposed and rubbed by travel barefoot—there is a tendency toward forming something like a scale. At any rate, Nature has put the material there for building something of the kind. The corn on the foot is only Nature's response to the same thing. She seems to say, "If you are going to keep on rubbing this place, I shall have to harden it for you." If you continually press a region already near the bone and rather gristly, she gradually deposits bone into it, and you have a bunion.

So doubtless the fish got its scales in the places and at the time when it had need for them. Perhaps as they glided between things the sides needed pro-

tection and scales formed here first, as they do yet in the little fish as it grows. In some cases, though not in all, this growth in the little fish, it is quite likely, shows where scales may have first formed in the race. Take this without proof now, for we will have to refer to it several times before we reach the proper place to try to show more clearly why a little fish in getting its growth seems to explain the manner in which its family got certain structure.

In the carps now, where, by selecting the least scaly, we try to make a scaleless kind, it may be noticed that the scales along the middle of the sides are the last to go.

Whether brand-new scales are made to order directly from the skin or not, we may feel sure that in some cases Nature has formed some new *kinds* of scales out of old ones. The old dame is very fond of working up any kind of bric-a-brac a creature may have about it into something useful. In many cases we can see where two different kinds of scales come together—or rather blend into one that is neither the old nor the new—and yet is like both.

The sharks, rays, etc., have a very peculiar and original skin covering of their own, which is not scales at all. It seems more like a lot of little warts or pimples that first grew on the skin, and afterward became bonelike—or rather toothlike—not horny. Then, later on, a hard, glistening material like that on the outside of our teeth—known as enamel, formed on top of these little pimplelike projections, especially near their tips, and this kind of outside

skeleton—skin, bony points, and all—is called shagreen. It is a beautiful and elegant protection, and in this case the fish may be said to escape injury, not by "the skin of its teeth," but by the teeth of its skin, rather. We shall see later that a fish can easily grow teeth wherever they are needed, even outside of the mouth or inside far down beyond it.

Purses and other ornamental things are made of this skin tanned with these teeth left upon it.

Among the sturgeon forms, the style of outside covering that was fashionable at first was a lot of large, bony, squarish plates arranged in rows and placed edge to edge—not like shingles—as are the scales proper of the usual fish. In the old geological times some of these plates were enormous, as we shall see later. But even in this low group of fishes, scales proper began soon to show, and some of them now have them shaped like those of the bony fishes, though they are always much less rounded.

These squarish plates are usually called scutes when very bony, and they show the relationship of the fishes upon which they grow downward toward the sharks by frequently having enamel upon them.

It was the study of these scales alone, found in the rocks, that enabled the great naturalist Agassiz to tell us what kind of fishes lived in a long-ago age, and led him to set apart this soft-boned, enamel-scaled group to itself—an arrangement which has been of vast help in the study of fishes. Although it is now well known to students that the sturgeon forms blend into the bony fishes almost without a

break—one genus having both squarish scutes and roundish scales on the same fish—yet the old group (known as *Ganoids*) will be kept in fish literature because it presents to us a stage through which all the forefathers of our common fishes once passed.

It is reported that Agassiz, when a boy, said modestly, "I think fishes a little sometimes"; and the author is putting many things here in as simple a manner as possible that his young readers may be able to "think fishes a little," as well as see them and read about them. Too frequently we all—either in our cruelty, greediness, or vanity—swallow, throw away, or wear on our heads or bodies many things that might feed our minds with delights if our mental tastes were properly trained.

In the bony fishes the rule is: scales proper or no scales at all. But there are some exceptions here also, where great bony plates, of so many different shapes that we can not describe or figure them all, may be found. In some, as the trunk fishes, the plates are many and placed edge to edge so that the body may be bent, but other fish are immovably incased for a certain length in solid armor, almost like that of a tortoise (see Fig. 29, on page 60).

In the group known as the swellfishes there are all sorts of outside coverings. Some possess bony scutes out of which spines project, while in others, as the porcupine fish, the covering consists of spines only that are rooted directly into the flesh. Many other fishes have bony plates on certain parts of the body only, either with or without scales elsewhere.

Others of this swellfish group have the skin beautifully paved with thin scutes, like the squares of a checkerboard, or simply with soft plates of tough skin. Some gurnards, of which group the sea-robin is a member, have bony plates also. The alligator fishes and their kin are completely covered with about eight rows of bony plates, and their heads are

FIG. 29.—Trunkfish (*Ostracion quadricornis*), above. Rabbit fish (*Lagocephalus lævigatus*), below at the left. Trunkfish, three-quarter view, below at the right.

entirely bony outside. In ordinary scaly fishes the head also may be scaly, but it is often naked and skinny or warty.

In the mackerel forms some fishes have the scales behind the head projecting backward, forming a great collar or mantle about what may appear as a fish's

shoulders. We shall see that some fossil fishes had similar bony garments or shields long ago.

Other fishes are simply warty, or both warty and spiny, as the lumpsuckers; for, as has been suggested, skin-spines began quite likely as warts or pimples, and were filled with bony matter.

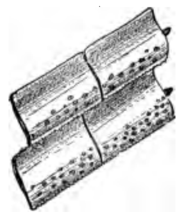

FIG. 30.—Ganoid scale.

Scales proper are divided into three kinds.

The first are those that are squarish, called *Ganoid* scales (here shown, Fig. 30). They have already been described as belonging mostly to the sturgeon forms. Some of these, however, show a tendency to change into the ordinary scales. As noted, both kinds are found on the same fish. By looking at this picture of our American garpike (Fig. 31), which is a sturgeon form, you will see that in the arrangement of these scales there is hinted the nice rows and general order of the scales on the higher fishes.

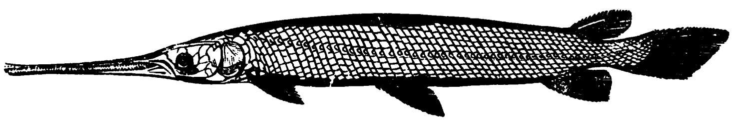

FIG. 31.—American garpike.

The ordinary or roundish scales are of two kinds. The simpler form is called *Cycloid*, because they are quite roundish in outline, and their rear or fore edges are rather smooth or merely roundly scalloped (see

Fig. 32). By close examination it may be seen that the scale consists of a series of thin layers, the bottom one oldest and largest, and each one above is a little smaller than the last. So also some scales that are very thick show that, in getting into their present proper shape, they have wrinkled a little in the rear. These are doubtless closer to the squarish *Ganoid* scale, and may have been made from them; they are found mostly on the *lower* division of the bony fishes, where the rays are soft, etc.; but the line is

FIG. 32.—Cycloid scale.

FIG. 33.—Ctenoid scale.

not a clear one, for some higher fishes also have them. Mackerels possess both this and the next kind on the same fish.

This next kind of scale is called *Ctenoid*, from a Greek word that means a comb, because they have, on their rear or free edge, teeth or sharp notches (see Fig. 33). They show many other peculiarities, one of these being that they grow in layers. In some cases each one of these layers has had its notches on the rear edged as it formed, and these seem to have turned up, and when the scale is complete they form rough points or short spines on the hindmost surface of the scale. They show also certain foldings and

wrinkles in their shape. We may call them "toothed scales."

They are found, with exceptions, rather in the higher of the bony fishes. They are probably the last form of scale that was made.

Scales lie, on full-grown fishes, as do the shingles on a roof, where they are put on regularly. In little fishes the scales do not overlap, but only touch edge to edge,. like those (Ganoid) of the sturgeon forms (see Fig. 31, on page 61). By comparing the picture of any scaly fish with that of the garpike, a similarity of arrangement can be noticed. Scales are of great help in describing fishes and distinguishing species from each other, though they are no longer used in separating the great groups. Still, we might take a little review of them, noting how the various kinds are, with exceptions, largely associated with certain of the great divisions. Thus:

1. Shagreen—on shark forms only.
2. Squarish enameled plates or *Ganoid* scales—on sturgeon forms.
3. Roundish smooth-edged scales, or *Cycloid*—largely on lower bony fishes.
4. Roundish tooth-edged scales, or *Ctenoid*—largely on higher bony fishes.

TALK VII.

How a fish knows the world and what it seems to know of it; or the senses of touch, taste, smell, hearing, and sight, and their corresponding organs.

A FISH, like many other creatures, knows the world by means of its outside covering, for it is by this that it comes in contact with its surroundings. While scales, spines, etc., may appear to touch and feel, yet they only carry the force by which they come in contact with whatever they meet, back to the skin, where the real sensation exists. The greatest feeling organ of an animal is the skin proper.

The skin of fishes is not much unlike that of the higher creatures. It has an outside layer which is not sensitive—that is, has no feeling in it—beneath which is the true skin. This forms the envelope that contains the entire body. There can be little doubt that a large portion of the outside parts of fishes are formed from their skins, and that from its folds have been developed scales, fins, rays, spines, etc.

Not only the bones covering the body, but those that form the head and cover the gills, are formed directly from the skin. They are called dermal bones or skin bones. There are some low fishes whose skulls are formed of dermal bones only.

The skin of fishes does not appear to have *in* it

the various glands that are found in the higher creatures. While it has many openings through it from which mucus is discharged, it does not secrete mucus. The mucus comes from glands that are under the skin. Perhaps much of the slime we find on the outside of fishes is due to the softening, by the water, of the old worn-out skin into a sort of jelly. We shall bring up the subject of mucus under another heading. (See Talk IX.)

While speaking of the uses of the skin, it is as well perhaps to say here that fishes, like frogs, turtles, etc., are able to breathe by means of it; but more about this will come up under BREATHING.

TOUCHING.

As hinted, the skin is the first great organ of touch, and it has nerves especially sent to it for this purpose.

In the fishes, as in ourselves, some places on the body are more sensitive than others. Usually these are at certain points which are used in feeling to find out the shape and location of objects. Like other things, the sense of touch is developed at places where it is most required.

As noticed, these places need not be always bare, for scales, spine, rays, etc., and other hard things, as our finger nails, may become agents of the sense of touch, because they move certain delicate nerves at the ends where they grow from the flesh. This is the case, as is well known, with the hairs about the mouths of cats, rats, and many other beasts.

But as they have these hairs, and we have our fingers and the tips of our tongues, so fishes have special instruments for finding out the shape and size of things by feeling. Some of these we have been compelled to notice as we have come along.

Besides having some rays of the fins separated from the others for this purpose, fishes have barbels, or little fleshy whiplike strings that grow somewhere near the head, by which they may feel their way when approaching a rock, the bottom, or their prey.

A notable and common example of this is the common catfishes of our creeks and rivers, where there

FIG. 34.—The burbot (*Lota maculosa*).

may be as many as eight of these feelers (see Fig. 1, on page 2). The codfishes and also some others have at least one of these, projecting directly down from the lower lip, as if to prevent them from scraping themselves on the bottom.

The barbel, the burbot (Fig. 34), the sand cusk (Fig. 18, on page 36), the loach, and others, are similarly armed. From this the former gets its name. The loach feeds under rocks and feels for its prey.

So well do these help the fish that it is said that blind codfish, by their aid, have no trouble in keeping fat and thriving. Among the deep-sea fish barbels are found in great abundance, where, on account of there being no light, much must depend upon feeling.

Barbels may have other uses, as we shall see later. As a rule, they show at once that the fish is a bottom feeder or, at least, a still-water haunter, since these flimsy strings could not be directed toward an object in a strong current.

Some fishes, as carps, chubs, and wrasses, have very sensitive lips or noses, which they use in the search for food.

TASTE.

Close akin to touch is taste, since the food must be touched to be tasted. While fishes have means of distinguishing their food, their sense of taste does not seem to be keen. They are led more by touch, sight, and smell, but at times they gulp without judgment anything floating within their reach. It is likely that taste can not enable them to greatly enjoy their food, but merely to judge of it slightly. Their chief enjoyment seems to come largely from a sense of fullness.

In those fish which are vegetable feeders, as the carps, the food is often chewed for some time before it is swallowed, in which case they probably taste as they eat. So likewise in others which crush shellfish and such things before they swallow them, the sense of taste may be considerably developed.

In general, there are some nerves of taste spread out on the tongue (when a tongue is present), and others are scattered on the palate or far down the throat; but there is in no fish such an ample array of taste-nerves as there is in the higher vertebrates.

Smelling and the Nose.

Fishes smell very well. Since they do not breathe air, the odors must come to them through the water. As a rule, the nostrils of fishes are closed at the rear, and do not open into the mouth as do ours.

All fishes proper have two nostrils. In the two low groups, the lamprey-forms, there is a single nostril.

Only in the hagfish (a lamprey-form) and in the lungfishes does the nostril open into the mouth. The latter in this way show a tendency to be like the higher animals, in which smelling is always connected with breathing. Doubtless some of the water which is breathed by lungfishes passes the nostrils. But in other fishes this can not be the case. They could still smell if they "held their breath," but such fish really have no breath to hold.

It seems remarkable that the organ of smell is not placed in the gill-cavity, where so much water passes.

In some eels and other fishes there are two pairs of nostrils.

Hearing and the Ear.

Fishes hear very well, especially when they are in the water. The author has frequently clapped his

hands above a school of little fishes, to see them suddenly sink.

The ear of the fish is a very simple affair, and is usually in itself closed, having neither outside form nor opening. Our ears open both outward to the air and inward to the throat, but in the highest fishes there are neither of these passages, except the carps and codfishes, where there is an opening into the mouth.

The ear of a hatching fish forms on the outside as a little closed sac filled with fluid, and sinks into the head as the creature grows. In the shark forms the tube or path taken by this sac as it goes in, remains open during life, and has a flap or valve over it; but it is not known to have any other use than to show us how ears were formed. The higher bony fishes have no such opening, and the ear is far inside the head, having bone all around it.

But in the carps and the loach the ear is connected with the air-bladder by means of a series of bones, and in some others there is a more direct connection by means of canals. It is not at all improbable that this enables the fish to better feel jars (or vibrations) of the water.

The internal ears of the true fishes are very imperfect in comparison with those of man and the higher animals. But they are similar to the higher ears in always having three little bones present inside of them.

Lancelets have no ear whatever. Lampreys have only a sac with the rudest parts in it, while the ear of the hagfish is simpler still.

A fish does not need so good an ear as do the land animals, because it does not so largely seek its prey or escape its enemies by means of hearing. Its whole body and nervous system may help it feel the jar at the approach of an enemy on land, much as deaf persons become sensible of heavy sounds.

Along the sides of fishes is a line called the lateral line, made up of peculiar scales, beneath which there are great numbers of nerves, as though it were in some way a sense organ. Some have thought that it means special touch here, but it seems that it might be as probable that the purpose of these nerves is to appreciate (feel) vibrations or jars of the water.

Another use of ears in fishes is to hear the call of a mate, for it now seems fairly well known that, at some seasons, certain fishes push their heads above the water and call, or rather speak, so that their sweethearts or friends may hear and come to them.

Eyes and Seeing.

The eyes of fishes are not much unlike those of other backboned creatures (vertebrates). They agree with those of snakes, lizards, frogs, etc., in having the transparent outside skin run over the balls, which are not movable. Usually a fish's eye has no true lid that can be winked as ours can. But some sharks have a sort of little membranous kerchief in one corner of the eye which can be swept over the ball to clean it. Owls, chickens, rabbits, and others have the same. It is called a nictitating membrane, and is in no sense a lid.

Some fishes have, however, a fold of skin around the eye which looks like a lid, though it is not movable. At certain seasons the false lids become enlarged or very fat, so that they answer for a sort of ornament. This reminds one of the practice of some birds which put beautiful colors about the eye on special occasions, and of some other biped beauties who are said to pencil their eyebrows and darken the lashes.

Of course, swimming in the water all the time, a fish has no use for a lid to sweep moisture over the ball, as we have when we wink; and since tears were made primarily for this purpose of dampening the eye, there are no tear glands in fishes; they do not express their feelings in that way. But there are some fishes that crawl out on the land and look around. One of these, the mud-skipper, pulls its eye down deep into the socket and rolls the ball over backward till the front part is directly backward, and thus well moistened, when it is again ready to look around well. It sweeps the ball under the lid instead of the lid over the ball. This play of the ball enables this fish to thrust its eye far up from the head also as it looks around. It can thus at will make itself as "pop-eyed" as it pleases. See how very frog-like it is in its expansion! (See Fig. 21, on page 43.)

Perhaps the most remarkable eye in any backboned creature (vertebrate) is found in a fish for which there is no English name. It is called *Anableps*, from this peculiarity of eyes (see Fig. 35, on page 72). You have seen that style of spectacles in which the glasses are made of two pieces—an upper

and a lower. The upper is a half of one lens of a certain strength to see far off with, and the lower is the half of another more powerful lens made to see things near by.

Now this fish has eyes that are similarly divided. The upper half of the ball is shaped to look far off *over* the water, and the lower half is shaped to see near by *under* the water. The fish is a surface feeder, and may look out both ways for food or foe; and if the surface is calm it can see into the two "elements" at the same time by getting its head just right. There are two holes (pupils or "sights") leading into the ball, and consequently the fish is really double-eyed.

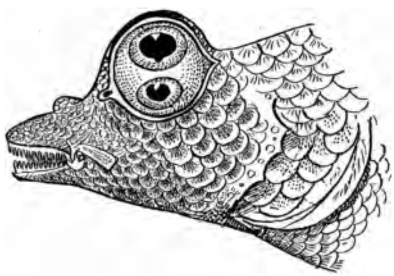

FIG. 35.—Head of four eyes (*Anableps tetropthalmus*).

In the location of the eyes about the head, fishes are very variable. Eyes seem to be placed where most needed. Usually, as in our sunfish, they are well back on the sides (see Fig. 1, on page 2). In others they may be lower, but especially higher. Fishes that feed on the bottoms, or look for their food there, seem to depend rather upon feeling for it or prodding it up with their snouts than upon seeing it directly. This may be because such food is usually hidden from sight under sand or mud. At any rate, very few eyes are directed downward.

In such fishes as lie on the bottom in wait for their prey, the eyes are set close together on the top of the head, so that they may look up well at passing things. We have seen that this is the case with others which, as the mud-skippers (see Fig. 21, page 43) and star-gazers, climb out on land and look around. Here they are placed high up for this purpose.

The rule is that both eyes seem to have moved upward till they came close together, as may be seen in the rays, angler, the dragonets, and others. But in the flatfishes (see Fig. 11, page 24), which lie on one side, the eye beneath has crept around on the upper side and stands near the other. In very young flatfish the eyes are as they are in a perch or other ordinary fish.

As noted, the hammer-headed shark has its eyes on large, fleshy stems, sticking out from the sides of the head (see Fig. 13, on page 27). Unless these stems are projected above the water so that the eye may look around, it is hard to see their use.

It is well known that snails have their eyes on fleshy stems, which may be thrust upward for watching.

In proportion to their size, young fish have much larger eyes than the grown ones. This is true of many other creatures. Some fishes have such large eyes as to show strongly that they are night prowlers. Indeed, it is well known that most fish are night feeders, even many, as our catfishes, which swim near the bottom But fishes sleep sometimes—not with

FIG. 36.—Phosphorescent deep-sea fish.

their eyes shut, of course. Many, because the forward fins are not working then, lose their balance and hang head downward as they doze. We can see here again a reason why the paired fins are often set so far forward.

Deep-sea fishes also frequently have large eyes, evidently to allow them to see in the weird phosphorescent light, like that of fireflies, which may be made either by themselves or their prey. It is not improbable that here some fishes are bright, to attract prey, just as a candle attracts moths, a beacon draws birds, and a light lures fishes themselves to approach it. Many of these deep-sea forms carry a special lantern in the shape of barbels enlarged at the end, and some have certain fatty spots which seem, perhaps, to furnish oil to burn slowly. But of this later. (See Fig. 36, on page 74.)

What concerns us now is that here in these great depths only are found fish actually or totally eyeless. Others have imperfect eyes left—remnants of what were once good and useful eyes when their forefathers swam nearer the surface, for it is quite evident that deep-sea fishes came of kinds that did not begin to exist (originate) in these great depths. Some of them have lost their eyes, just as certain moles have nearly lost theirs, because they ceased to need or use them.

It has been thought also that certain peculiar pearl-colored spots on these deep-sea fishes are not so much for the purpose of giving out light as for *feeling* or appreciating it; that they are a rude sort of eye

that in these great ocean depths is beginning to develop. It is the belief of some students that the eye began as a cluster of colored grains (or cells upon the surface of the skin), which could *feel* light but not see anything. Such so-called eye-spots are seen on many insects. These would be useful to these deep-sea creatures in showing them when they were nearing a light or the surface, though the lighter or heavier pressure of the water surrounding them tells them this latter.

Whether this be true or not, the lowest of our fish forms, the lancelet, has for eyes only such flat color-specks on the surface of the skin, to which the merest thread of a nerve runs. Since color-stained cells like these are all clustered together away back in the ball of every perfect eye, this eye-spot of the lancelet and those of deep-sea fish seem a little as if they were the beginnings of eyes, though that of the lancelet may be the ending.

There can be no doubt that with the eyes removed or covered many creatures can tell when a faint light even is shining on them by feeling it with their skins.

That Nature has put much work on the eye of the fishes is shown by the large lobes of brain which she has devoted to its use. Out of these is sent really a stream or tube of the brain—one to each eye.

An interesting thing about these so-called optic nerves is that, as they run from the eye to the brain, they meet in a sort of stalk before they get there in all the shark forms, they cross each other, but their

fibers lace into each other in the sturgeon forms; in the bony fishes they cross each other clearly without joining at all. In the hands of a skilled naturalist the great group that a fish belongs to may be known by its eye nerves.

Perhaps it may not be out of place to add that in all other creatures also that are above the fishes these optic nerves cross, but are grown together at the crossing.

TALK VIII.

How a fish looks its best and makes the most of its accomplishments; or the expression of eyes, mouth, jaws, etc., and other ornaments and their display.

THE eye of a fish is very expressive, even when it is dull and small, as in the catfishes and sharks, or large and leering, as in the rays. The eye of our little sunfish is open, frank, and mischievous.

There is, too, in the cut of the body and sweep of the tail much that might be called "style" in fishes. If we consider their movements, we call them graceful Perhaps in all Nature there is no more graceful motion than the rapid swimming of some of the more stylish fishes, as the mackerel or trout, or the gossamer-like floating and settling downward of some of the perch-forms and carps. In graceful curves of outline, also, a fish is not excelled, even by a bird.

We have already spoken of the head as affecting the shape, and of course it is a large feature in a fish's expression. The graceful head of the herrings and others adds much to their beauty. Since in our very natures we love speed so much, we are apt to admire anything which indicates it. Grace of form is invariably associated with shape for speed. A wide, thick head, therefore, can not be so pretty in a fish as a sharp, thin one.

As in other things, nothing affects a fish's expression more than the mouth. It may range from a mere pore or pinhole opening, at the end of the snout, to the most tremendous slit, almost from one gill to the other. This slit may be straight across—as is usual—curved upward, or sloped downward at the corners of the mouth, all of which positions give very different expressions of greediness, sorrow, or humor. That of the catfish (Fig. 1, page

FIG. 37.—Forkbeard (*Phycis blennoides*).

2) is an illustration of the first; that of any of the perch-forms, with the lower lip dropped, well represents the second; while the pert look of the little trumpet fish is expressive of a readiness for fun.

While the mouth has to be always about the head, it is located variously upon it, and, like other things, it is placed where it will be of the most use to the

fish. We can usually judge a great deal about the place where a fish feeds by looking at its mouth. Those feeding on the bottom are apt to have it situated very low down on the end of the head, and in

FIG. 38.—Mousefish (*Chironnectes lævigatus*).

the case of some, as the rays, it is placed far back, appearing as if it were under the body.

There appears to be an exception in the sharks, which are known to feed now largely on floating things. In most of these the mouth is far back under the head, and they have to turn on their backs before they can seize their prey from the surface of the water (see horned dogfish, Fig. 19, page 37). Since it is quite evident to the student that this kind of shark has come from kinds that once fed on the bottoms, we can easily see how the habit of turning over has prevented the moving forward of the mouth. In a few sharks the mouth is well at

the end of the head. Look at the cut of the white shark (Fig. 8, page 19), and note how well adapted it is for scooping up things as it swims over them. As we go on we will find much to convince us that all sharks—in fact, all fish—were originally bottom-feeders. In very old geological times the first sharks lived where there were plenty of shellfish, and they fed on these, as is shown by their having then crushing teeth only and no cutting teeth whatever. Now in all our dangerous sharks the teeth are lancelike.

FIG. 39.—The Bergylt, rosefish, or Norway haddock (*Sebastes marinus*).

In the lowest fish form, the lancelet, the mouth is a mere vertical slit in (or rather under) the front end of the body, since the creature has no true head.

Of course, the lips affect the expression very much. What could be more sorrowful than the lowered lip of the bergylt here figured? It has such a literally "down-at-the-mouth" appearance! (See Fig. 39, page 81.)

Of course, the fish is not sad, but has just dropped its lower jaw to scoop up some favorite morsel.

But the lips proper may be very thick, as in the wrasse, where quite an African thickness is found. These lips are made so, of course, as tools for delicate feeling. Lips are not very prominent things about a fish. They are capable of very slight motion, unless they move with the jaw. Sometimes they take on several folds and appear double, but the rule is that they are stretched closely about the edges of the jawbones.

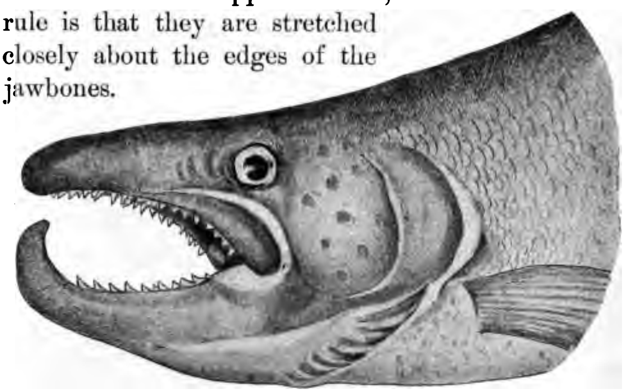

FIG. 40.—Curved under jaw of salmon.

JAWS.

The most expressive feature of the mouth is the jaws. In some fishes the upper jaw can move, but

the rule here, as elsewhere, is that most of the motion is in the lower jaw.

FIG. 41.—Bones of the lower jaw of salmon.

It is by the "set of the jaws" that expression is so frequently given to fishes as well as to people. In the pikes the lower jaw projects with a sort of vicious look. In the salmons this jaw, at the spawning sea-

FIG. 42.—Trumpet or bellows fish (*Macrorhamphosus scolopa*).

son, grows longer in the males, and curls up into the mouth. It may be that the male thinks that this makes him look pretty; or it may be that Nature means to

strengthen the upper jaw as he butts his rival. Possibly it may be meant simply to make the fish appear frightful as it opens its mouth at its foes. There are many such terrifying implements in Nature.

Did you ever see a boy threaten another with a forward set of his lower jaw?

Sometimes the two jaws combine to give the fish a peculiar expression and a remarkable form of mouth. Thus in the garpike (Fig. 31, page 61) of our waters they both project far forward, almost of the same length, and they are terribly armed with teeth; while in the saury pike of Europe the lower jaw is the longest, and the two when closed appear much like the beaks of some birds. Instances of this are many. In the pipefishes, the trumpet

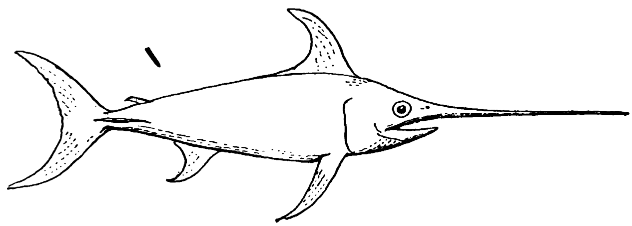

FIG. 43.—Swordfish (*Xiphias gladius*).

fish, and some others, these long jaws are joined into a slim tube, with a very small opening at its end.

In many cases the jaws combine to form a sort of parrot-like beak with cutting edges. In the so-called parrot wrasses the teeth and jaws are so fused together as to make a beak for scraping corals, on

which the fish feeds. Many others have parrot-like beaks.

But it is the upper jaw that usually projects the more, and gives, as in the swordfish here illustrated (Fig. 43) and sawfish, so much to shape and expression. In these it is a weapon, as it is in many others;

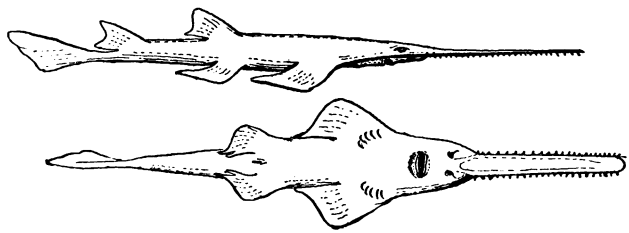

FIG. 44.—Sawfish; profile view, upper; view of under part, lower (*Pristis pectinatus*).

but in the paddlefish it seems to be more of a spoon, or spade rather, with which to stir up the bottom.

More of this will come up under WEAPONS AND FEEDING HABITS.

Of course, every external part of a fish affects its expression. The spines of the globefish and porcupine fish give them a formidable and forbidding look, and the expression of our little sunfish is made more fierce by the spines in the fins.

So also the beauty of the fish is improved by the graceful cut and shape of the fins, as noted, and the beautiful and orderly arrangement of the scales, along with their splendid luster and metallic burnish.

Aside from this, yet connected with it, there

comes, to help a fish in looking its best, that most ornamental thing in all Nature—

COLOR.

Fishes rival birds and butterflies in the splendor of their colors. So many scales are beautiful, not because they are stained, but because they reflect beautiful tints, as do mother-of-pearl, soap-bubbles, glass prisms, etc. Only those birds whose colors are the result of this peculiar kind of sheen can rival the prettiest fishes in beauty.

There is no need to attempt to describe these. It could not be done if we had ever so much space. Even in such fishes as trout, mackerel, and others, where the scales are not in sight, the colors of the skin are like the hues of the rainbow; and in some cases they are equally variable just at the time when the fish is snatched from the water, so that they can scarcely be painted at all.

COLORS IN THE DIFFERENT SEXES.

While in many instances, even where the fish is brilliant, the colors are the same in both sexes, there are many others in which the male is the brightest and prettiest, as is the case in the birds and insects. It often happens, too, that this pretty dress of the male is put on only at the spawning season, when he is very anxious to make a good appearance before his sweetheart. These colors, therefore, seem intended to help the wooer to win his mate by charming her with his beauty.

Thus he may be seen sometimes showing off to her, and sometimes, when fighting a rival, these colors flare up beautifully, as if they were meant for defying or taunting.

The Siamese have some little fighting fishes which, when pitted against each other, fight like gamecocks. The moment they begin they become much more brilliant. This may be due to any struggle, as we noted in the case of the mackerels.

We shall see later that many fish can change their colors by the will when they choose.

The instances where the males are colored for charming are very numerous, but the salmon-like fishes, the pikes, the sticklebacks, are common examples. It is especially apt to be the case with such fish as fight for their wives, and the beaten rival may be said to "lose his colors" literally in defeat.

There is a large literature bearing on this subject (among all the insects and higher creatures), some of which, it is to be hoped, you may read when you are older, for it furnishes a key to the purpose of many of the pretty things in Nature.

It may be well just here to note some other queer ornaments that fishes put on for charming purposes. Many males extend certain rays of the fins into long needles or threadlike filaments, and these are often beautifully colored. Such is the case in the family in which our little "shiners" or chubs belong. A very noticeable case is that mentioned by Mr. Darwin, where the lowest ray of the tail-fin is thus prolonged away out behind.

One of the catfish group also has stiff fringes, like hair, on its gill-covers, so that it really appears as if it had a beard. One of the male *Chimæras* or spook-fishes has a horn upon the head, while the female has none; but this may be a weapon. Many male chubs, as noted, have the heads warty at the social season, and smooth the rest of the year.

Returning to our general topic of the colors of the body, it is said that it has been rather recently proved that if, in aquariums, the light be thrown upward, and cut off from above—reversing the conditions in Nature—the lower part of the fish, which is usually light-colored, begins to get darker and the upper part becomes lighter-colored. This would seem to hint that the colors of the fishes are due, in part, to the direct effects of light—a fact that has been denied. Many fishes, though not all, in caves and other dark places have lost their color, and are white or limpid; but in the great depths of the ocean, where no light comes, the fish are not white or colorless (like clear water), but are said to be usually pearly or black. Some of these may wish to hide, hence the black; and others, as the lovers we have been talking about, may wish to be seen, and these pearl-colors may show well in their faint, fire-fly-like light. (See Fig. 36, page 74.)

Phosphorescence.

We have seen that certain fishes may glow as a firefly (lightning-bug) for purposes of lighting the way or luring prey; but in this topic we must notice the fact that their light is probably used, at

times, as an ornament or advertisement. We are sure that this is the use made of it by fireflies and glowworms.

Many ordinary fish have a tendency to show phosphorescent light, especially when they are decaying. This, it is said, is because they have so much of the substance called phosphorus (which you see on the ends of matches) in their flesh. From the way this substance behaves in the air, we know that, as it glows, it is slowly burning, producing light without heat. While we do not understand it, we know also that fireflies, glowworms, etc., produce light with scarcely any heat; but when we human folk get light we must heat some substance very much before it glows.

It appears that many fishes—especially the deep-sea kinds—have found a way of slowly burning their old worn-out skin, and their mucus, so as to make a light. In others, as we have noticed, there may be special fatty places that glow. In either case the glow may be as much for ornament as for use, since some half-civilized belles wear brilliant fireflies in their hair, and some rather civilized boys wear electric lights in their scarf-pins. We value diamonds, opals, and other gems because they sparkle; and it is noticeable that we wear these things so that they may sparkle in others' eyes rather than in our own.

The habit is an expensive one for us, but fishes seem to get quite as much glory out of their old clothes by burning them, and, to reverse a Biblical expression, really put on ashes for beauty.

As we have seen, however, they may have certain spots where *new* matter is consumed; and in these cases at least, and in the special lantern-like barbels, the fish must be alive to keep the light going. This light soon ceases in a dead fish.

Two of the head-fish, the salt-water sunfish and the moonfish, are said to be so called because the great body of the first named and the smaller body of the latter glow in the dark, like luminous disks in the water.

Something more of how a fish makes itself agreeable will be noted under the topics, *Nests*, *Shoaling*, and *Care of Young*.

FIG. 45.—Silver moonfish or lookdown (*Selene argentia*).

TALK IX.

How a fish escapes from its foes and slips through life rather easily; or protective colors, means of escape, and mucus.

Before leaving the topic of colors, it is best to mention those that seem to help the fish hide itself. They are called protective colors usually, because they protect the fish from being seen by its enemies.

It is not at all probable that all the colors of a fish are useful to it. Some may result from the peculiar kind of growing or decaying skin it has, or from the kind of food it has eaten. The flesh of the salmon is said to be colored by the color of its food. But there are many cases where we can easily see that the colors and color-markings are of great use, since they blend so well with the colors of the place where the fish usually swims or lies.

Generally speaking, fish are all darker on top and lighter on the bottom. The color of the back is usually much like that of the grasses and other matter on the bottom, or like the deep shadows that lie over pools. An enemy, in looking down, can scarcely see the fish for these, and if it glide beneath the fish, the white under parts of the latter are not unlike the sky seen out through the water. Hence this *ar-*

rangement of colors, as well as the colors themselves, is helpful. Here, then, is a reason why the under parts of fishes are generally lighter than the upper parts.

But there is another reason, and this applies to birds and beasts also. If an enemy be looking neither from above nor below, but on a level with his eyes, at a creature so colored, the latter will not be so easily seen as if it were colored alike all over. Since the light always comes from above, the dark top of the fish is the better lighted and does not appear so much like a black blotch; and the under side is poorly lighted, but, being brighter, is perhaps as easily seen, though it is in the shadow, and hence does not appear as a light blotch. These colors are so graded into each other that they make the fish seem of about the same shade of color all over, and it appears flat, not round and solid, to its foe; and may be not seen at all if it keep still. It has by this arrangement of colors killed the effects of that light and shade which make things look solid. This is the reason that we can not see the squatting quail, woodcock, or hare easily. It appears as a mere flat spot upon the grass or leaves, and does not stand out at all as a rounded body. If these birds were colored all over alike, they would be much more readily seen.

You can, by a very simple experiment, convince yourself of the truth of this. Make two rolls of mud or clay and dry them. Paint or chalk the under side of one whitish, gradually shading off fainter up to the middle. Leave the other plain, and lay

both on the same mud or soil from which they were made. Step slowly away, and you will see that the unpainted one can long be seen, but that at a short distance the painted one has disappeared from view.

This interesting discovery was made recently by an American artist, Mr. Abbot H. Thayer, to whom due credit should be given. It furnishes a key to the location of much of the shading in animals.

Besides simply having the colors solid and like the bottom of the stream in which they swim, you will find many fishes with fainter and deeper colors running variously across or along the body. When among grass and the reflections of stems, etc., in the water, such markings are doubtless very helpful in hiding. This sort of coloring and arrangement of colors is found in a great many kinds of fishes. The common barred perch is a familiar example.

A similar use of colors may be seen in fishes when they wish to hide from their prey as well as from their enemies. A striking instance of this occurs in the flatfishes, which lie on the bottom waiting for some luckless thing to swim over them. This can be observed in almost any public aquarium. As a flounder lies flat on its side, with its wing-like vertical fins flattened out and their edges pushed a little way under the sand, the coloring of the upper side is like that of the bottom. Even the warts and pimples upon the rough skin seem to be for the purpose of imitating grains of sand and small pebbles, and have all the pretty colors and shadings of the little stones. The effect is like that which we see on the stage in

theaters and panoramas, in which it is hard to tell where the real objects cease and the painted ones begin.

Likewise many fishes are protected by filaments or barbels which so much resemble in shape the bottom grasses, weeds, etc., that the distinction is not easily made. Thus in some these strings end in at least two flat, thin disks, that resemble the roundish leaves of certain plants near by. In other instances the filaments are colored in bands of brown and orange, in almost exact imitation of the seaweed on or in which the creature lives.

Many of the colors of which we have been talking are permanent, but some fishes, like certain frogs, the chameleons, and other reptiles, have the power of changing their colors, within certain limits, to suit the color of the material on or among which they may rest. This, as in the case of the other creatures, is done by means of sight; for if the fish be blind there is no change, no matter what colors are about it.

This power is not confined to any one family of fishes, and it is quite probable that more fishes possess it than we yet know of. The gobies, pipe-fishes, some sticklebacks, and some flatfishes—especially the plaice—can, in a few moments, make their complexions suit their surroundings.

There can be little doubt that other fish have some sort of slower control over their color. The author has found the same species of mountain trout much unlike in color in differently shadowed pools of the same creek; and in different but connecting

streams there can be seen more or less changes in the shades of the fishes' backs.

Escape.

Of course, fishes escape their enemies by other means than hiding, and they hide more directly than by merely resembling something about them. Many bury themselves quickly in the sand or mud. Our little chubs of the branches are said thus to hustle themselves out of sight tail first when frightened. This is also true of the cusk, which hides in the sand.

Others dive quickly under rocks, or dart among weeds, brush, or into shallow places. As a fish grows large it gets wiser and is very much afraid of shallow water, because this exposes it to its enemies on land or in the air. Little fishes, therefore, that are apt to be swallowed by the larger ones, feel safer in shallow inlets or ripples where their foes can not come; and hence they are so often seen there. Therefore in our streams large fish are found in deep water.

But other fishes depend for safety upon their speed and dodging tactics, as the hare escapes the hound. Many interesting habits are here observed, especially in the ocean, where shoals of one kind pursue shoals of another kind of fish.

Our space permits the mention only of that most interesting and well-known example practiced by the so-called flying fishes. (See Fig. 25, page 49.)

When pursued by a foe or otherwise frightened, perhaps by a vessel (which they doubtless think is something terrible), they rush toward the surface with such

speed that they are projected as an arrow into the air, where they sail by their broad, long, wing-like pectorals, much as a bird may do with half-closed wings.

There has been much discussion among observers about *how* these fishes fly, but it is rather generally agreed that while the fins seem to be moving as they go, the flight is not by means of flapping. The motion seen in the fins may be merely a fluttering made by the passing air, as is that of a flag in a breeze.

Their flight may be as much as the eighth of a mile or more, though it is often much shorter, depending on the force of the start in the water, perhaps, and upon the condition of the wind. As with all sailing creatures, it may be longer against the wind than with it.

At times flying fish are seen to dip into the crest of a wave, when the sea is rough, and by the rapid use of the tail get a new start. Usually the flight is not above three or four feet from the surface, but it may rise to fifteen or twenty. It is said to be higher at night than in the daytime.

It is a matter of much dispute whether these fish can turn in the air or not. The most trustworthy observers seem to think that their course is changed only by the wind blowing them. They can rise and fall a little at will.

Besides the true flying fishes found in our American waters, there is one, a species of which is also found in the Mediterranean Sea, called the flying gurnard, which also flies fairly well. It is akin to the sea-robin. (See Fig. 25, page 49.)

The true flying fishes are closely allied to the bill-fishes, which have very long, slender beaks. When young they have two little barbels beneath the lower jaw, which *may* possibly hint how much these little fishes have risen in the world—from bottom feeders to fliers.

Many other fishes skip some distance out of the water when pursued, often throwing themselves far out on the shore.

Mucus.

While there can be no doubt that a fish slips through the water more easily because its whole body is slimy, it is equally probable that it sometimes slips out of an enemy's grasp by the same means.

The topic therefore is not out of place here. Besides this, the mucus of some fishes is disagreeable, if not poisonous.

Mucus of fishes seems to be a secretion from the inside largely, which comes out through small openings all over the body. Some students, as has been mentioned, believe that the worn-out skin of fishes becomes slime, and helps to keep the body slippery. We know that many parts of a fish can be used in making glue, especially the air bladder.

But along the sides of most fishes there is a distinct line known as the lateral line, which when examined closely is seen to consist of a series of small holes or pores. These open *through* the scales. Sometimes around these pores the scales rise up into high, horny, or pearly points or ridges, which make

the line quite noticeable. Usually there is only one of these lines, but there may be more. They may run only part way of the fish, or all the way from head to tail. In some fishes the line runs entirely out upon the tail fin. In all these cases it is very helpful in describing and knowing the different fishes. (See Fig. 16, page 32.) In many, however, it is absent altogether.

As already noticed, the lateral line is very bountifully supplied with nerves beneath, and it is thought by many students that it may be some sort of sense organ. This, it is very likely, is true. The lateral line is found in some of the amphibians, creatures higher in the scale of living beings than are fishes. Below the fish nearly every creature is slimy.

Deep-sea fishes have much more mucus than surface fishes, and in them the lateral line is very wide, showing its evident connection with mucus. In many of these the mucus is phosphorescent.

Some fishes have much more mucus than others. Those, usually, that have the most can live longest out of water. Eels and all the low forms of the bony fishes are very slimy, especially the catfishes.

Perhaps in keeping with our general topic of how a fish escapes its foes, there is no more striking example of the use of mucus to baffle an enemy than that of the hagfish. It is able to pour out a thick fluid, through certain holes in its skin, so rapidly that the water all around is made into a sort of jelly and the creature is hidden. If one of these fish be placed in a bucket of water and then be irritated

or frightened, it will quickly convert all the water into a jelly nearly as solid as that usually made for the table.

In many cases the lateral line is crooked or wavy, showing how the fish has recently changed its shape by enlarging some part of its body. In our little sunfish you can see how the body has been widened upward rather than downward, and that its forefathers were once round, slim fishes, having, as is usual in such fishes, the line running straight along the side (see Fig. 1, page 2). It is said that in such fishes as do not have this line there are no special nerves in the region.

Armor, Spines, etc.

Of course, a fish escapes its foes to some extent by means of scales, tough skin, and especially by bony armor when present; but they have been discussed in Talk VII along with the skin, to which they are so closely connected.

A fish is likewise protected by various spines, as many an angler has learned when trying vainly to tempt some old bass to bite at a little spiny sunfish.

But all these things more properly come under the next talk—about Weapons.

TALK X.

How a fish fights its foes and makes itself disagreeable generally; or weapons, electric organs, and poisons.

We have been speaking of how a fish escapes its foes, but have said little about how it may defend itself. There was just a hint that the mucus of some fishes was disagreeable and that spines were likewise offensive. This brings us to weapons which may be used either in defense of self or young, or in the pursuit and destruction of prey. They are therefore known as offensive or defensive weapons, but the same instrument may have both uses.

Few classes of creatures have more kinds of weapons than fishes, or more ways of being disagreeable.

The first weapon is the mouth, usually with its array of teeth, though all fish do not have teeth. But this weapon is not new, for from the earliest creatures the mouth has always been the means of securing prey. To swallow an enemy was thought to be the easiest way of getting rid of him, and gave a double enjoyment, satisfying both anger and appetite.

Really, we might say that the stomach was the first weapon in Nature, for the lowest creatures known have no mouths, but, being liquid, jelly-like animals, literally flow around their prey and digest it.

The teeth of fishes, with possibly a few exceptions, are set for seizing and holding prey. Some, set far back in the throat, are pointed or hooked backward, and are intended to aid in swallowing. In such fishes as do not capture fleeing things, the teeth are often arranged in pavements, like stones in the streets, or they may be fused into plates which are used merely for crushing. Many others, especially those of the sharks, are lancelike and are evidently intended for cutting up creatures too large to swallow whole. Many fishes, as the eels, can bite out pieces of flesh clean at a snap.

The other special form of weapon about the mouth is usually found in the projection of the jaws. We have noticed the case of the lower jaw in the male salmon growing very long and curling up and back till, when the mouth is closed, it rests in a groove of the upper jaw (see Fig. 40, page 82). This may be intended to strengthen or stiffen the upper jaw, for these fishes and many others fight, somewhat as sheep do, by charging at each other and ramming their snouts together, or, if possible, butting into each other's ribs.

Now this is a kind of weapon that seems intended to use on a rival only—a member of the same family—if, indeed, it is a weapon at all, and not an ornament. If we were carefully classifying weapons, we might distinguish this kind as belonging to those that are put on at the time of rivalry and shed when the season is over, as is the case with this salmon's jaw and the horns of deer, etc.

But such terrible weapons as the jaws of the swordfish and sawfish (see Fig. 44, page 85) seem to be intended for use against large enemies belonging to other tribes than the weapon bearers, the whale and others, where deep lancing is necessary to kill. The sawfish uses its saw as a butcher's tool, as well as a weapon, for with its help it rips open the bodies of its victims at a stroke, and is thus able, if it chooses, to devour the entrails only.

The weapon of the swordfish is a terrific blade, and has been driven through the copper sheathing of ships and as much as fifteen inches of solid wood beyond. Men sitting in small boats are sometimes killed by this monster as it thrusts its sword up through the bottom and pierces their bodies. Its great swimming powers have already been noticed; we may infer them from its form.

While speaking of these charging or butting fishes, we might say that some of the rays appear to have horns; but since these creatures are not capable of speed and are very lazy, it is likely that these instruments are used as fingers to help them get their food into their mouths. They seem to have been formed from part of the pectoral fins which, as we saw, have in some of these creatures run even beyond the head.

The great rays, known as "devil-fish," which are found sometimes as large as fifteen by twenty feet, may strike, when swimming, terrible blows with these fins, thereby killing great sharks which attack them. The wings of birds, it is well known, are very effective weapons, and are sometimes armed with spurs.

In the smaller rays and in the flatfishes a very good defense is found in their shape. When a turbot is flattened on the bottom with its continuous row of spines spread out all around it, there is very little of the fish at which an enemy can bite except the flat, leathery, warty upper side (see Fig. 11, page 24). Besides this, these fish have the power of fastening themselves to the bottom by pressing out all the water from between them and the surface upon which they rest, to which they stick so tightly as not to be easily loosened. In something the same manner boys fasten their circular suckers to the pavement by forcing the air out from between the well-soaked leather disk and whatever surface it is placed upon.

Sailors shorten their ropes very quickly after striking the devil-fish with a harpoon; for if it once gets thus sucked down to the bottom they are often unable to raise it, even after it is dead.

The unicorn fish is peculiar in that it has a single long horn extending from the tip of the snout, running upward and bending backward. This horn is said to be made out of the spine in front of the dorsal fin, and is not a part of the jaw at all.

The use of this implement can only be guessed at. It may be a weapon, used, somewhat as the rhinoceros uses his horn, by striking it upward under the tender parts of an enemy; or it may be a terrifying instrument only. In caterpillars there are many of these horns, that are used merely to make the creature look terrible, and thus frighten off an enemy. Bluff is

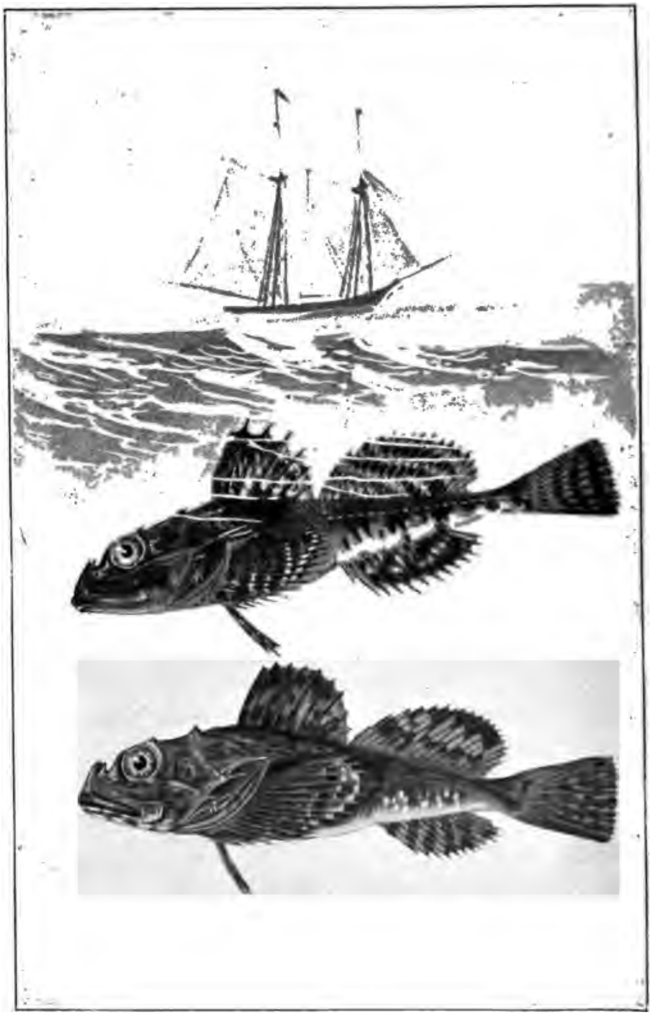

FIG. 46.—Common sculpin (*Cottus octodecimspinosus*), upper; Greenland sculpin (*Cottus grœnlandicus*), lower.

something animals as well as boys, men, and even nations, often depend upon to gain their ends. Perhaps the use of this horn is to prevent the possibility of being swallowed "head-on" by some larger foe.

In many cases, spines, besides being sharp and thorny in the fins, are developed into great daggers, sometimes with sharp edges like knives.

FIG. 47.—Sea porcupine (*Diodon maculata*), upper; the swellfish, globefish, or burr fish (*Chylomycterus geometricus*), lower.

In such cases the film that forms the fin is gone; the spine, merely as a weapon, is left standing alone. In some sticklebacks there are several of these purely defensive or offensive spines.

Spines as means of defense are not confined to the fins only. We have seen how they may spring from the scales or be rooted in the flesh. A great many fishes have them about the gill-covers and bones

of the head and lower jaws, as, for instance, the sculpins (see Fig. 46, page 104); while others, as the porcupine fish, globefish, have them all over the body (see Fig. 47, page 105).

At the other end of the fish, the tail is often a weapon itself, or carries one or more upon it. The

FIG. 48.—Fox-shark or thresher (*Alopius vulpes*).

fox-shark (Fig. 48) is called the thresher, because it is said to thresh its enemies with its tail. Sailors say that it leaps into the air and strikes the whale such terrible blows that death is caused when they are oft repeated. This fish is said to use its tail as a scaring or terrifying device. It threshes the water till it foams, and

the blows make great smacking sounds which frighten smaller fishes until they become confused, crowd together, and are easily caught.

There is a family of fishes called the surgeons, because on the sides of the tail they have a sort of lance-shaped spine with which they can cut an enemy as they swim past it.

Likewise the rays (not the skates) have often many spines upon their slim tails, which they may strike into either their prey or their foes.

Bathers are frequently sorely wounded by the spines of fishes, especially by those of the sting-ray. In many cases the spines are barbed or are notched with teeth set pointing away from the tip, so that they are hard to pull out and make a ragged wound. This would imply that, quite likely, these creatures pierce small fish and other things that swim near them, since these barbs are set backward so as to hold in well or wound badly, as a fishhook or a harpoon. But some catfishes also have these notched spines in the pectoral fins, where their use seems to be purely defensive.

The spine of the sting-ray reminds us of another way which fishes have of being very disagreeable. Some of these rays make wounds that sting a long time after the puncture is made.

Many fishes have a poisonous slime or mucus which constantly flows over the spines, so that when they are thrust into the flesh they are very painful. The spines of our common catfish, of the inland creeks, have this effect to some extent. In fact, the mucus of all fish is perhaps slightly poisonous.

Although in this case the spine does not seem unusual in shape, there are in other fish found various modifications of form that fit the spine for a poisoning instrument.

Thus there is a family known as *Scorpanoids* (because of their venomous sting) which have spines covered on each side with a little poison sac, placed near the tip. When the spine is thrust in, the sacs remain closed, for they open toward the tip; but as it is extracted the poison is stripped away and left in the wound. Beyond the sacs are small grooves, down which the poison flows.

This sort of groove is found in the fangs of some serpents also.

In other fishes there are found spines which are hollow tubes, with poison sacs at the base. In this case the poison is pressed through the tube as the spine is thrust in. These correspond to the hollow fangs of serpents, which have become tubular by having the edges of the grooves folded in, as one may see by studying the tooth or fang when cut squarely across.

One of these fishes, called *Thallassophryne*, is found on the Pacific side of Central America. It belongs to that peculiar family known as the frogfishes, near which is the angler or fishing frog.

In this case the fish is a bottom haunter, and while the poisonous spines on the back seem purely defensive, it has similar spines, which are not so, on the gill-covers. It may be that by bending the body and throwing the head around suddenly, these latter can be

FIG. 49.—Shanny (*Blennius pholis*), upper; weever (*Trachinus draco*), lower.

used in direct attack—perhaps to paralyze passing prey, as some snakes are known to do. The poison from this fish is said to be as deadly as that of the most poisonous reptiles.

Usually poisonous creatures tend to develop more fully under the tropics; and a safe plan in this region is not to wade in waters barefooted.

The great weever (Fig. 49)—sometimes called sea-cat—has also poisonous spines upon its gill-covers.

The most remarkable weapons that fishes have are those peculiar organs, or fleshy batteries, whereby an electric shock can be given to an enemy or prey. Nowhere else in Nature is such a means of being disagreeable found.

It does not seem improbable that some other creatures might have it, since it is found among the fishes in such widely separated families as rays, cat-fishes, possibly in some of the kinsfolk of the globe-fish, and most notably in a so-called eel. The batteries also in these various fishes differ very much in structure, in location, and in the sort of old material out of which they are made. Nature was building batteries out of scraps of waste material long before man existed.

In all these peculiar organs there is much the same thing in one respect, in that all seem to have a great number of little cells filled with plates immersed in a jelly-like substance. This last seems to be the exciting fluid. The plates are vertical in one fish and horizontal in another.

But, while the organ is necessary to the shock,

it can have no action, it seems, without the aid of the fish's nervous system, for large nerves run to it, and if these be cut no shock can be given. The current, therefore, is under control of the fish.

The current from some of these organs is very severe, and it might seem as if it were made so by the great number of cells being connected in series, though there is no evidence whatever of the manner in which they are connected. To such little readers as have played with electric batteries, the piercing voltage would seem very naturally to be made in this way, since the current has been shown to have the same effect as that from a galvanic battery.

The shock from the most powerful of electric fishes, as the electric eel of South America, is sufficient to stun a man, or even larger animals, and it may be used either to take prey or defend the fish. All these fishes are naked-skinned, so that good contact may be made.

In all these electric fishes some sort of contact seems necessary, though this may be made through a good conductor. In the electric ray, or torpedo, the top of the body is said to be positive and the bottom negative. Of course, one hand on the top and the other on the bottom gets a shock; so one foot on the fish and the other on the bottom of the ocean receives the current, because the underside of the fish is "grounded." But it is difficult to see why the current does not run right around the fish (short circuit) in the water.

It is said that a man directing a stream of water from a hose upon a torpedo got a severe shock.

The electric eel—so called, for it is not a true eel—is said to give its shock by touching both its head and tail upon different points of its victim's body.

FIG. 50.—Torpedo (*Narcacion marmorata*).

A great shock can be had from the captured fish by touching it at these different points—one with each hand at the same time. Possibly in the water a touch at a single point would answer, as is the case with the torpedo.

It is said that the electric catfish can shock by the mere touch of its nose, though its current is not nearly so strong as that of the others.

Besides these means of being disagreeable, there are many fishes whose flesh is poisonous—at least to man. It is doubtful if this is really intentional on the part of the fish or Nature, and it may be no protection at all to its natural enemies.

Man, you know, is not a natural enemy, but the most unnatural. Many creatures who have never seen him have at first no fear of him at all.

The flesh of these fishes is reddened often by their food, such as medusas, corals, etc., which are poisonous to us. Others may eat of decaying flesh, likewise hurtful to man but harmless to many other creatures. Along our southeastern coast and around Cuba are found many such fishes, that produce severe sickness when eaten.

Sometimes this happens at the egg-laying season only, when the eggs of certain fishes are also hurtful.

TALK XI.

A glance inside of the fish at a few of the things it keeps there; or mouth, teeth, gullet, stomach, etc.

THERE are a few fishes whose places or kinships can not be made out unless some one should cut them open. The outside parts may appear to teach us something about the fish which would be wholly misleading and wrong. In many other cases, those persons only who have captured or seen vast numbers of specimens are able to say, merely from its outward appearance, what sort of fish it is which they have, and what are its habits.

Now we are going to profit some by their dissections, and yet not have to cause pain or death ourselves, or have to smear our hands with scales and blood.

To those of us really interested in fishes the inside structure is very helpful in telling us much of their habits and something of their history. Even to those who care for the fish's ways, movements, and external things only, these parts are of interest, because they may show how these other things are done.

Suppose that you saw for the first time a locomotive engine standing dead and cold—not upon a track

but upon a platform—and that you had not heard of its use. The flanges on the wheel would make you curious. Why not flat? Where do they fit? What are all these pipes for, this lever here, this sand box, and all these cams and rods? Why can not the wheels turn without them?

And then these grate-bars, what are they for? And look at this—this large, hollow, stomach-like thing! What do they put in that, and why do they put it there?

Then if some one should place it on a track, steam it up, and make it move, your joy would be great because you could see all these things act their parts.

Suppose that, on the other hand, your first glimpse of a locomotive engine was as it dashed by you at a mile a minute, and you had only a blurred image of a whirling, rushing, roaring, snorting thing—no one part seen definitely. Your interest would be wildly stirred, and the first impulse would be to follow it up, as a boy would follow a band-wagon, and study out its structure in the hope that you might see how it did this.

Many a boy has thus studied machinery, and found out what it does with the things it has, or how it performs its wonders.

Be a little patient now for the next few talks, as we look a little into the grate, the liquid circulation, the fuel arrangements, and the fanning-up apparatus of our little locomotive which runs under water.

Teeth.

As we look into the mouth the first thing that we see is, quite likely, the teeth. These are often very numerous, much scattered around, and of various shapes. A few of the fishes are destitute of teeth. Many do not have any on the jaws; but the rule is that you may find them almost anywhere from the lips to the throat.

Indeed, we need not look into the mouth at all to find teeth, since, as we have seen in the case of the

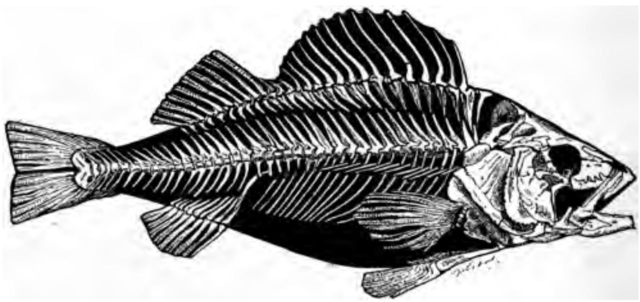

Fig. 51.—Skeleton of a perch.

sawfish (see Fig. 43, page 84), the long, projecting jaw is armed with them on each edge for a yard or more outside.

Like nearly all other things, many of the teeth in fishes appear to have begun to grow from that peculiar skin which lines all inside cavities, called mucous membrane, but they may, after they become hardened, grow down to the bones over which they begin. Sometimes, however, points from these other

bones have grown up into the tooth. This meeting of outside and inside growths is a rather frequent thing in the animals. The spines in the vertical fins in fishes are so met, or reached after rather, by others in the flesh below, and these are reached after by spines on the backbone. (See Skeleton, Fig. 51, p. 116.)

Some teeth of fishes are set in grooves, some in sockets of the jaw, a little like our own, but many of them always remain fastened merely to the skin or flesh.

A few are attached to the bones by tough, gristly fibers in such a way that they may be bent down the throat (as the prey is swallowed), but not bent outward. Thus anything has small chance of getting out when it once gets into the mouth of, say, the hake or pike. Many other fishes possess this kind of teeth, and especially the angler.

It is stated that all fishes shed their teeth at intervals during their entire lives, having a constant supply of new ones to come in or on. Sharks usually have their teeth in at least three rows. As fast as the outer ones are worn or shed, the next row moves to the edge of the jaw and begins to be used.

Fishes seem to have literally all kinds of teeth, both in size, shape, and structure, as well as in situation and methods of shedding and growth. They range from mere bristles or roughish stubs to great fangs for cutting, or to great floors or pavements for crushing. They may be in patches, rings, or bands, or they may be massed into great unbroken plates. These plates are often found in the throat, in such fish as crush shellfish for food. In the parrot-wrasse, and in some

headfish, the teeth are fused together around the edges of the jaws till a sort of parrot-beak is formed, very useful in cutting off corals, etc. Other teeth are arranged for gnawing. It is said that the filefish can gnaw through shells as a rat. Others, as the carps, which eat vegetable food, have teeth with grinding surfaces, like those of grass-eating quadrupeds.

Mr. Huxley has claimed that even the short, pearly spines on the skin of the sharks have all the structure of true teeth. On the contrary, in the globefish family, the mouth is formed of a bony or horny layer, which is of much the same material as that found in the beaks of birds. These fishes, therefore, in material have true beaks.

To know the shape and structure of teeth generally is very important to the naturalist and geologist. The great group to which a fish belongs can often be known by a single tooth. If this be not evident by its shape, the surface after the tooth is sawed in two will sometimes tell a great deal. It often happens that all that is found in the rocks is the fish's tooth, but this enables the student to tell much about the swimmer that roamed these old seas whose bottoms are high and dry now. Fishes' teeth may have peculiar grooves or folds in them; they may be hooked at the tip, and a few are barbed along their length, as a fishhook.

Tongue.

In the salmon and a few others the tongue even is armed with teeth. In some of the hagfishes the end

of the tongue is thus armed, and the creature literally licks its way into other fishes. In these and the lampreys the tongue is round, and fills the circular mouth as the piston fits a pump. By this means they are better able to suck themselves to an enemy and to draw its blood.

Often, however, the tongue of the fish is not easily distinguished from a sort of fold of the floor of the mouth. Rarely does it have much motion, or at least the power (capacity) of being extended outward. If a fish wishes to throw anything out of its mouth, it may cause the floor to heave it up and thus get rid of it; but the creature often simply shuts its mouth quickly, so as to cause the water to rush out and carry the rejected thing with it. Fishes *seem* to be great tasters, though they can really taste so little. They take into their mouths many things that are unfit for food, and appear to be able to tell by feeling that they do not want such stuff.

When the tongue is absent there usually remains, however, the bones beneath it, on which, in all vertebrates, the tongue is built; showing, perhaps, that their forefathers had tongues, and these modern fishes have lost them. But in the catfishes the tongue-bones even are gone. As already noticed, the tongue in fishes seems to receive few nerves, and can not, therefore, be of much account in tasting.

Pharynx.

Behind the tongue in fishes is a space or cavity which is not the mouth or the throat. It is just in-

side of the gills, and because it is connected with breathing, as it allows the water to pass from the mouth outward, it is called the pharynx.

In some large fishes, so great is this space, which is filled with nothing but water, that, as we shall see, other little fishes make their homes here always.

Throat.

The throat of most fishes is large, and usually permits the swallowing of great lumps of food. Often, though, as we have seen, there is placed just in the entrance to the swallow or gullet a great plate of teeth for crushing the food.

We have already seen, when speaking of how far forward the anal fin may run, that the body cavity of a fish is very short. In a few instances, as in flatfishes, headfishes, etc., the rear opening is directly under the throat.

In all cases the whole digestive tract of a fish is quite brief, often much shorter than the length of the fish. This will appear more remarkable when we consider that in many beasts it is often more than ten times the length of the body.

The Gullet

is the plain English name for the swallow-tube that leads to the stomach. It is necessarily very short. It has no folded pockets or expanded places in it which form crops or craws, as in the birds. The stomach is, of course, such a pouch as this, but there are some rather high fishes, as those of the flying-fish family

and many of our little chubs in the creeks, in which there is practically no stomach, the gullet itself storing the food for a while.

In the very lowest of the fish-forms the gullet runs entirely through as one continuous tube, without any change in size and with very little change in direction.

THE STOMACH.

In the higher forms of fishes there is usually an expansion of the gullet into a pouch, called the stomach, and the tube is usually bent directly upward back upon itself at the lower end of this pouch. It seems quite likely that the bend-

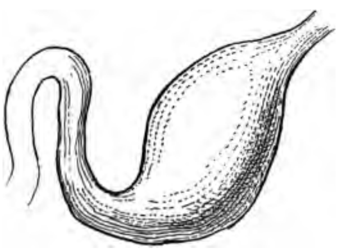

FIG. 52.—Siphonal form of stomach.

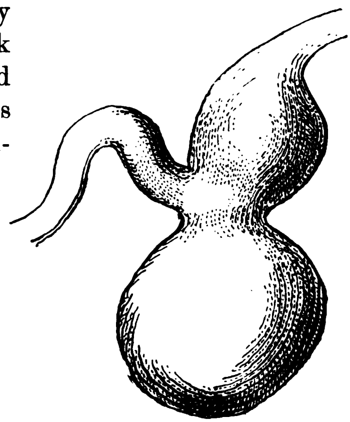

FIG. 53.—Cæcal form of stomach.

ing was first and the pouching was later, because very naturally the food would tend to be stopped by the bend, or be dammed up there (Fig. 52).

Now in some cases, after the tube was bent up, as in the accompanying figure, a long sac was formed directly beneath this bend, as shown in Fig. 53.

This also might seem to have been formed by the weight of the food at the bend.

The first form of the stomach is called *siphonal*, because it is bent like a siphon, and the second form is called *cæcal*, because it has a sac. *Cæca* means sac.

It is not expected at all that you will remember these names, but these two kinds of stomachs are very useful in identifying some fishes. Thus the salmons and their kin have a *siphonal* stomach, the smelts have the *cæcal* or latter kind. There is no other way of knowing these fishes from each other in all their sizes.

We will not dwell longer on the other details of the digestive tract, except to say that in the shark-group there are some spiral folds in the lower part of it, to keep the food from passing through too rapidly. These were set up, quite likely, before the stomach was so perfect. We know that sharks had them in the long ago, because some of their food found fossil (petrified in the rocks) has the marks of the spiral folds in it yet.

In fishes, as in birds and others, the form and structure of the stomach may vary with the kind of food. Those that eat flesh, which is easily digested, have simple, thin-walled stomachs and short digestive tracts beyond; but those that eat vegetables and other indigestible things have thick-walled stomachs usually, and a digestive tract below which is much twisted about. Thus the mugil, one of the mullets, and the gizzard-shad, have true gizzards.

In many fishes there are, at the lower end of the

stomach, a lot of little worm-like tubes closed at their lower ends, which are very helpful in knowing or describing the species.

But of all the fishes, some of those known as the deep-sea fishes possess the queerest of stomachs.

In some of these, as the bottlefish and the black swallower (see Fig. 5, page 11), the stomach is the chief thing, and the rest of the fish seems merely as a handle attached to it. So great and expansive is this pouch that the fish can literally "get outside of" creatures that are much larger than itself—often as much as three times larger.

They throw their great mouths and hooked teeth over some part of their prey, and, while it still swims about, they gradually stretch the stomach about it, finally taking it all in and digesting it.

Sometimes, however, the prey succeeds in struggling up to the surface with its foe attached. Then, because the great pressure of the deep sea is removed, the swallower is killed or made helpless by the expansion of the gases in its body. It often bursts, or is so swelled as to die.

The swellfish, however, swallow great quantities of air, till their stomachs are puffed out. On these there are usually spines, which by this swelling are made stiff and more threatening. The globefish thus floats bottom upward, being in this way well protected above and below while it rests. (See Fig. ~~16~~ 17, p. 109.)

Doubtless other fishes thus swell themselves to appear very frightful, as do frogs, toads, snakes, and even man when trying to bluff some one.

Liver.

Perhaps we need say nothing of the structure and location of the liver in fishes, except that, in the lowest, it is a mere sac on the side of the digestive tract, and that it assumes much importance in the higher forms. Besides doing the usual duties of livers, it here seems to become often a reservoir or storing place of a soft fat or thick oil. Many fishes are taken for this liver-oil only—that of the codfish being of well-known use. Because there is much of iodine, bromine, and other medical elements in the sea, and because a fish's liver, like our own, is much affected by what it drinks, this oil is curative in many diseases that humanity is heir to.

Other interesting things are found inside of a fish, but many of them can not be noted here. Some come up in the next talk, some in the one after that, and others in the following chapters still.

Then we shall talk of some more interesting outside things again, which you may like better.

TALK XII.

How a fish gets its breath, and, with only half a heart, keeps up its circulation; or gills, heart, and blood-vessels.

Since some fishes breathe by means of the digestive tract, it may be as well to take up here the topic of respiration, or how a fish gets its breath.

It is well known, of course, that we and all the beasts breathe by drawing in great quantities of air and blowing them out again, all at regular intervals; but respiration is more than this. We might puff in and out the world full of air, but that would do us no good unless the oxygen in the air was taken up by the blood and afterward given up from this to the muscles and to other things which need to move and grow.

One sometimes feels as if about to smother when the heart is not working right. This shows that the topic of circulation is closely connected with that of respiration—in fact, is a very essential part of it.

In all the backboned folk, and many others, the rule is that there is a certain place where the blood is brought so close to the air that the oxygen—the life-giving and moving (energizing) gas of our atmosphere—can ooze or pass through the thinnest kind of a membrane directly into this blood. Some sort of

movement must therefore be given to the blood, and this is usually imparted by the contraction and expansion of sacs, bulbs, or great muscular organs called hearts, which are situated somewhere in the midst of the blood-vessels.

In some creatures, as the insects, for instance, the air goes into the body at a great many different places, so that the blood needs to flow scarcely at all, or just to ooze along very slowly. But elsewhere, a favorite method of Nature for giving oxygen to the blood was, even long before the fishes, by means of pumping that liquid into little tufts, threads, or cells having the thinnest of walls outside and being porous on the inside, so that they may be easily filled. She placed these anywhere about the creature; and since so many of the animals swallowed air as they ate, these little gill-tufts, as we shall call them, were often found inside of the digestive tract below the stomach.

Some fishes also have these gill tufts so placed now, and it is probable that in the earliest times they all breathed largely by swallowing air just as they now swallow food. Even yet many, that have good gills in the usual place still, keep up to some extent this older method of breathing. One fish (*Callichthys*) breathes very largely in this way, and is therefore able to remain out of water twenty-four hours, and in dry seasons to travel overland to other pools when that in which it has lived has dried up.

We shall see in the next talk that Nature in the past took pains, apparently, to make a storing place for air, to be breathed at leisure in this manner.

But it is by means of these gill-tufts, located in a certain place on the side of the head, or neck rather, that fishes usually breathe now; and in most cases these gills are no longer tufts or filaments, springing from one place like a bunch of grass, thus,

but they are usually in the form of a rather regular fringe with a stiffened support running along the back, thus,

These fringed gills are found in fishes only, but the tufted gills belong to many creatures below them and in a few above them.

It is quite probable that all fishes once had these tufted gills. Some very young fishes show this kind

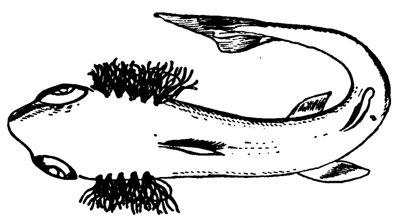

FIG. 54.—Young dogfish, showing outside gills that afterward disappear.

of gills yet, especially as they are hatching, but they have the regular kind when grown. Such are the sharks, and some of the sturgeon-forms, lungfishes,

etc. Likewise the pipefish family has this sort of gills all the time.

All the amphibians, as frogs and salamanders, when they are young have tufted gills, worn on the outside, and some (few) of these keep these tufts all their lives.

Doubtless at the time when the fishes and the amphibians separated from each other away down in the past, both were wearing these tufted gills on the outside; and it is hinted, as we shall see, that both were beginning to form lungs also. But of that later.

The fringed gill was a new thing in Nature at the time of the perfecting of the fishes, and, as noted, belongs to the true fishes only. Usually these are arranged along bony or gristly supports or arches which are situated inside the neck or well back in the mouth cavity.

In common fishes there are now four of these (a fifth one having been lost), and they swing free from each other and from everything else, except that they are fast at each end.

Between them are spaces which are called gill-slits, but in all fishes above the sharks these do not open on the outside, because they are covered by a sort of scale-like bone called the gill-cover.

But in the shark-forms there are as many outside openings as there are gill-slits, and there is no covering at all; here also the gill-supports are not free, but are grown to the skin all the way along the openings. These are called gill-arches.

If we look at the gills of the higher bony fishes closely, we can see places where there were once more openings in their gill-covers also, there being distinct creases or scars where these extra slits have grown up. This fact of a single opening and many openings makes a great and easily noted distinction between the two great divisions of the fishes. There is, however, one group of fishes, lying between them, which have the gill-covering of the bony fishes rather, but much of the structure of the sharks otherwise. It is the spookfishes, or *Chimæras.*

A distinction between the sharks and rays may usually be made by noticing that the sharks have the gill slits on the side of the neck and the rays on the bottom. These are usually five—in a few cases seven.

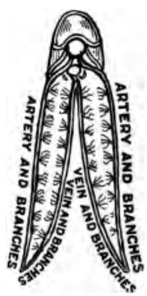

FIG. 55.—Diagram of circulation of blood through the gills.

The single gill-opening on each side of the neck of the higher fishes is usually a large slit extending from the top of the body around far under the throat, where it almost meets the other. But it may vary much in size. Sometimes it is only a roundish hole *through* the bone which forms the gill cover. In one family of eels the two slits run into each other and form a single opening directly across the throat below.

There are about the gills many neat arrangements for keeping them clean, erect, separated, and in the best condition for usefulness. Space will not permit the mention of them. The main object in all this is

that an abundance of water may pass over the fringes and give up its oxygen to them. Nearly all water has air in it, and it is from this air that the fish lives and moves.

The act of breathing in a fish consists in opening the mouth, allowing the water to enter, then closing it and, by contracting the gill cavity, forcing it out over these fringes. They are all so placed that the passage of the water in this manner keeps them well separated. It is said that if a fish be dragged backward through the water it will soon drown or perish for air, because this causes the gills to clog and close up. So, likewise, if a fish has its mouth kept open while in the water it will die, because it can not breathe properly except by using its mouth to force the water past the gills. Some other creatures have a fringe of fleshy threads (*cilia*) around the opening where the water enters, so that, by working these, a current may be made to pass over the gills.

Like ourselves, a fish must breathe faster as it moves more rapidly, for the more breath the more energy. The act of breathing in a fish helps it move a little bit, for the closing of the gill-covers forces the fish forward, just as some shellfish move by suddenly closing the halves of their shells.

In the lower fish-forms the manner of breathing is very interesting, but too difficult for our discussion.

In the lampreys and hagfishes there are several sacs along the sides into which the water flows from the mouth. In a few cases these sacs send tubes into the gullet, so that water may be swallowed into them.

In some there is an outer opening for each sac, in others only one for all the sacs. On the whole, the arrangement can be seen to hint, in a rather general way, at that found in the sharks, though this may be rather accidental.

In the lancelet the water enters the mouth, fanned in by a lot of fleshy strings, thence it passes through a great number of slits, near which are the breathing surfaces; then it drops into the body cavity and runs out by a special single pore. Around each of these little slits noted there are fringes or *cilia* which pass it on. Since the creature has no head or jaws, these are necessary to move the water. (See Fig. 10, p. 22.)

It is interesting to note that in many creatures below the fishes the gills are set on stalks or branches which can be thrust out and moved through the water, instead of having the water move over them. These are usually very quiet, lazy animals.

The oddest method of breathing is by the skin, as already noted. Many of the low creatures breathe in that way almost exclusively, by having the air go in at the pores; and not only the air but the water. It is well known that water runs into the muscles of fishes.

Fishes still breathe very much by the skin, as do their cousins, the amphibians, and some of the reptiles, as the turtles. So remarkable is this kind of breathing in water, that some frogs and salamanders, if the skin be kept damp, can live for months with the lungs removed; and a few fishes live a long time with the gills taken out.

In such fishes as breathe in this way there is a great network of arteries running to the skin, so that the blood may get its oxygen.

The breathing of fishes by lungs and air-bladders is an interesting topic, which we shall reserve solely for the next talk.

Circulation and the Heart.

As already stated, circulation must follow breathing, and is really a part of it.

In man and the mammals generally, as well as in the birds, there is a great muscular heart to send the blood to the lungs and to the rest of the body also. But in the reptiles and amphibians it is not so complete, while down among the highest of the fishes there is only half a heart. In fact, there are hints that the higher fishes have lost their heart almost, or at least part of it—a fact hinting many other things, as we shall see later.

Many very low creatures have no heart at all; the large blood-vessels simply throb (pulsate) at certain places. In some cases the blood is sent first one way, then back the other. In that lowest form of fishes, the lancelet, there is no heart.

But the true fishes all have hearts, by which the blood is sent in a circuit throughout the body. We have called a fish a half-hearted creature, because our hearts have four chambers while a fish's has only two.

To make up for this, however, the fish retains some of those old pulsating (throbbing) places, which have been mentioned, both in the arteries and veins.

They have become thick-walled and muscular, and act as assistant hearts. The fish simply has not bunched all its heart chambers together as we have.

These pulsating bulbs are very useful in classifying or distinguishing the fishes. Thus all sharks have such a shaped bulb, so located, so built, etc., and other fishes do not have such but have other shapes. These things, however, are too technical for us.

One of these bulbs pumps the already-used blood into the heart, and the other helps the heart to force it on into the gills and body. No blood that has a fresh supply of oxygen ever enters the heart of any fish which breathes solely by gills.

Only a part of the blood of such fishes really goes to the gills as it makes its round-trip; some of it may pass on by other branches, so that really all of it does not get to the air. The rest goes around again in the circuit. The fishes are therefore said to have a mixed circulation, because the aërated (brought to the air) blood and the already used blood are mixed.

The blood that is sent to the gills does not usually come again directly back to the heart before it is sent to the body (as it does in all cases where there are lungs), but it flows onward into the system.

There is an artery for each set of fringes, but there is also, in some fishes, a connection, as already noted, formed around each fringe by which some blood runs directly to those tubes beyond, which go on into the system.

Since little fishes, as they hatch, do not have any branches of the artery sent off, especially for the

fringes, one great authority is inclined to believe that fishes had a circulation that ran to lungs before they had a circulation by the gills—that is, that, in modern fishes, gills are really newer than lungs.

It is certainly true that, in the highest fishes only, does *all* the blood pass through the gills. We shall see later that in these higher fishes there are many other things which tend to show that gill-breathing exclusively is a recent method of breathing.

Of course, you have noticed how cold a fish is, even when alive and active. Its blood is cold, and the author has been a little tedious about these blood-pipes, that you may see one reason why it is that fishes are so cold-blooded. You note that by this arrangement all the blood is not aërated or heated—only a small part. In those creatures that have a perfect heart, *all* the blood reaches the air or lungs in every round, and hence is better heated. In them also the circulation is more rapid.

But really the blood of fishes is cold, more likely, because of the small amount of breathing surface they have, or because the water is so much poorer in oxygen than the air is. In frogs, snakes, and other creatures which breathe air, the blood is kept cool by this mixed circulation. As we have often seen, Nature does the same thing in many ways.

All creatures that haunt the water, or have had near-by forefathers that once did, have cold blood. It is a wise arrangement, so that they are not shocked by the great difference of heat between their blood and the water.

We would soon chill to death where a fish lives comfortably, unless we were provided with a great coat of fur or feathers, as are birds, seals, otters, etc., or with a great padding of fat, as are the whales and their kinsfolk.

It is often said that hot blood means greater endurance, but we are coming of late years to doubt that a little. Creatures are hot-blooded more likely, in part at least, because their exposed position outside of water demands it in order that they may keep active. The fish under the ice is not in half so cold a place as the boy who watches above to catch it.

We have seen how some fishes can convert nervous energy directly into electrical force without the aid of a dynamo, how some can get a light without heat. So also a fish can get great muscular power without so much heat as we have to get up when we exercise. A fish, as well as a mammal, gets hotter as it works, but what is meant is that we need not claim, as the books so often do, that hot blood or heat is the whole secret of energy. While we wonder at the gull or albatross, with its hot, pulsing heart, floating without a wing flap behind a vessel for weeks, we must admire the endurance of the shark or pilot fish that follows the same vessel, laboriously thrashing its way, with almost equal speed, through a much more resisting medium, while its skin is cold and snaky.

There is more in the *life*-power than the simple burning of fuel.

The heat of the blood is higher in some fishes than in others. In that of the mackerels (and doubtless

other active fishes) the temperature is greater than that of the water. The more oxygen blood gets the redder it is. It is claimed that the flesh of some active fish is thus reddened.

The blood is red in all fishes except the lancelet, where it is colorless, as it is in many other low creatures.

In the lungfishes (of which we shall hear more shortly), where there are rude lungs, the blood tends to be hotter, as it is in other air-breathing creatures. Since the sharks really have a better heart than the higher fishes, the arrangement hints that all fishes were perhaps more nearly warm-blooded once than they are now, and that they made a landward start from which they went back to the water—a hint found in many other things. This fact, combined with another, that in all higher fishes one of the gills has evidently been rendered useless (there being formerly five instead of four) shows that Nature has rather recently thought it best to make the higher, or bony fishes, cooler still.

TALK XIII.

How the fishes came near having lungs, and may have lost them or exchanged them for something better; or lungs and air-bladders.

PERHAPS in all the animals there is no little thing that is so curious to students as the air-bladder or swim-bladder of fishes. It may be present in one fish, and absent in its next of kin. It has one use in one fish, another use in another; in some it is connected with the ear, perhaps as an aid to hearing; in others it sends a tube to the gullet, perhaps to aid in calling; in many it is closed entirely, and is compressible and expansible, doubtless as an aid to balancing, rising, or falling; in others it appears as a storage-sac for surplus air in the system, a place where a fish puts up air as we put up ice, to be used in an emergency; while in a few others it becomes (or remains) lunglike, and in part helps the fish to get its breath.

In shape it may be a single sac; it may be in two or more parts, as if a string were tied tightly around a sausage; it may be divided lengthwise by a partition; it may have various pouches sticking out from it, like little stockings; it may be shaped like the new moon, or straight; it may be forked behind or in front; it may be single or double; it may have

pouches or sacs inside of it which do not show outside; it may be spongy inside, like a true lung; or the front part of it may be peculiar in some of these ways, while the rear is a simple sac only.

What do all these things mean? Would not anybody who thinks like to know that? Well, we never will know, but we can enjoy thinking about it.

The very lowest fishes, the shark-forms, do not have an air-bladder. We shall use the term air-bladder, because it is a more general term than swim-bladder. All air-bladders are not swim-bladders.

But the sturgeon-forms, which we arrange next above (though they may be lower) all have air-bladders. There are a great many individual species in the bony fishes that have none, but in the lower forms of these it is generally present. These lower forms are nearly all those which have the ventral fins set far back, and have jointed fin-rays and few or no spines.

It is not present in the lamprey-forms and the lancelet.

Among the bony fishes it is absent in all the flat-fishes, in the blennies, and in many of the eel-forms.

Now, while these exceptions exist, it is very noticeable, in a general way, that the air-bladder tends to disappear or be degraded as the fishes get higher in the scale from the sturgeon-forms.

It is usual to divide air-bladders into two kinds—those which have a tube leading from them to the digestive tract (usually the gullet or stomach), and those which do not have this tube (or duct) and are

entirely closed. There are cases, however, in which this tube is so small that it can scarcely be seen—in fact, it is spun out so fine that it seems just in the act of disappearing. Now we should not know which way this thing was going if students had not examined some of the young of the higher fishes as they grow from the egg. Here it is found that many fishes which have no duct when old do have one when young, and we shall show later how this settles the question about which way this tube is going. Evidently it has passed away in these high fishes, and the air-bladder with a duct to the gullet is the old original form.

While it can not be so easily proved, there can be little doubt that such of the higher fishes as have no air-bladder at all have lost it, because it ceased to be useful to them.

In connection with this loss, let us talk first of the air-bladder as a swim-bladder. There can be little doubt that many fishes use this sac to alter their bulk, so that they may sink or rise more easily. Such is the popular impression—in fact, it is usually believed to be its sole use. In the catfish family this bladder is surrounded largely by bone, and in one kind of this fish there is a bone that can be pressed down upon the sac to make it smaller, or possibly to press the air out of the tube to make a noise. In fact, the author thinks that this is very probably the use of this pressing, since it is well known that catfish "bellow."

In some other fishes there are evident muscles for

compressing this air sac; in a few there are special voice organs in connection with these compressing muscles. Such are found in an English fish called the John Dory and in some of the sea-robin folk, the gurnards. But we will talk of voice later.

That this air-bladder is capable of great expansion without bursting is shown by the fact that in fishes caught at great depths and brought to the surface it expands so greatly that they are helpless. They can not again go down into the depths, and it is said that sailors have to puncture the bladders with a needle, to enable them to store the fish in water tanks.

This great expansion, however, it may be well to note, is seen also in all the muscles and inner parts in very deep-sea fishes. When once on the surface they are unable to go down again, even if they are not killed by bursting.

It is highly probable that in many fishes where this sac was nothing but a balloon, having no other use whatever, there was no need for any tube, and it was lost. Then, quite likely, as many students think, these fishes acquired such habits as did not make it needful for them to rise and fall so often, and hence they lost the sac.

Thus the flatfishes are near akin to many others which have air-bladders (the codfishes, for instance), but we shall see later that in their present ugly shape and bottom-haunting habits they are a very old family, which, having no need to rise, lost their air-bladders. So also the mackerels, which have no air-bladders, are almost exclusively surface swimmers. At least they

never lie on their oars and sink slowly to the bottom, as you may have seen the goldfish do.

Likewise others which now have no air-bladder, but which have rising and falling habits, may not always have had such habits. While an air-bladder is doubtless a convenience, it is by no means an absolute necessity.

The case of the shark-forms can be quite likely accounted for by change of habit, already noted in connection with the low position of the mouth. As we saw, under Teeth, Tail, Fins, etc., the earliest sharks were ground-feeders, having flat teeth in pavements for crushing the things which the old ocean bed was then so rich in.

The rays may never have abandoned the habit, as have most of the sharks. While it is possible, of course, that they never had any air-bladders at all, it is not improbable that they lost them when their ancestors became purely gill-breathing bottom-feeders.

The sturgeon-forms remained mud-feeders, but kept their air-bladders for reasons referred to a little further on.

The author has not tried it, but it is said that if the air-bladder of some fishes yet alive be pierced with a needle, letting the air out, the fishes sink to the bottom and are unable to rise.

Now, in those fishes which have a large tube leading to the gullet, we can believe that the air might get into this thin pearly sac by being swallowed, and in such, at least, as have this tube very large this is doubtless true; for in some cases they have been seen

to come to the surface and gulp down air. But in those with very small tubes, or no tubes at all, the air must be obtained in some other way. It is supposed that it is taken from the blood (secreted). In all cases there are some blood-vessels on the inside of this sac, and in many there is a very special spreading out of small arteries and veins within.

The gases in the sac have been studied and found to be nearly always a mixture of the same gases which make our common air. In sea fishes this is mostly oxygen, the great stimulant, but in fresh-water fishes it is more largely nitrogen ; sometimes the two are mixed in just about the same proportion, though not exactly, as they are in common air.

Now here comes in a curious little fact of the kind that makes us think. It is said that if a fish be put into water which is poor in oxygen, and examined later, it will be found that much of that gas in the air-bladder has been absorbed into the system, and that the sac is much shrunken.

From this we may believe that the air-bladders act as reservoirs or storage places for air (surplus or not), so that in case of great need a fish can draw upon this, as a bear or seal draws in times of hunger upon its supply of stored fat. Since the same blood comes to this sac which is in the other parts about it, and which has already passed the gills, it is not improbable that the air-bladder may get oxygen from the blood, when that fluid has it in abundance, and yield it up again when the blood is deficient in this gas. In this way, even in its most degraded condi-

tion, any air-bladder may be connected with breathing or respiration. Having once taken this step, a great many suggestions as to how the air-bladder may help or may *have* helped in respiration begin to crowd upon us.

You recall how probably the early fishes breathed more by the digestive tract than fishes do now. They swallowed air. If we recall also that all early air-bladders were connected with the swallow or gullet, the hint may come that perhaps the sac's first use was as a place to store in air by swallowing, so that when a fish was in the mud (as the earliest fishes likely were), or at any other place where oxygen was scarce, this stored supply might be tapped. We shall see later that a very small amount of pure air will keep a fish alive for a long time.

In this way the air-bladder may be used yet today, along with some of its other uses in such cases, only, of course, where there is a tube leading to the stomach.

Nature seems to have been loath to part with this mode of aërating the animal's blood. Even in some amphibians she sends unaërated blood to the gullet near the mouth.

To the author it seems quite probable that this use is all the air-bladder has in some low eel-forms which burrow in the mud—one sufficiently useful to account for its not being lost in their cases. For this reason, quite likely, the sturgeon-forms, which yet plow in the mud and have bad water about them all the time, have retained theirs. It is in this great

group especially that the air-bladder is fitted by structure for this purpose, and the garfish and bowfin are found thus filling it, and going again to the bottom. But in these latter cases there comes in another rather awakening fact. While these two fishes, and many others which we can not now mention, take in air thus, some are noted as first spewing other bubbles out. Whatever the gases in these bubbles may be, there seems to be a hint of real breathing by the air-bladder, although the unaërated blood is not yet sent from the heart directly to it. Still it may help to aërate the blood further, at least that part of it which passes its way. This begins to look a little lung-like. This air-bladder may have either a present purpose, an outlook, or a history. Which?

In these two American fishes just noted, the air-bladders are double, quite like lungs in general, but their tubes still run into the back of the gullet, and the blood-vessels are still much like those of any other air-bladder, except that there are more of them. In an African fish, however, somewhat akin to them, the air-bladder is single, but it is divided into two parts and its tube enters the gullet *underneath*, as the tubes running from all true lungs do. Still, the circulation is as before. These are all in the sturgeon-group.

In another queer fish found in Australia—the mudfish (*Ceratodus*)—classed in the group of lung-fishes, the lung is yet single but has a double set of pouches all the way along its great length. In this case the heart does not send blood directly to it by a

special tube, so that the fluid may be aërated. The blood comes to it from the system as to any other air-bladder, but *it* sends the aërated blood to the heart by *special blood-vessels*, thus showing about one half of the peculiar arrangement which a true lung has.

FIG. 56.—The Ceratodus of Queensland, an air-breathing and water-breathing mudfish of the ancient type, with paddle fins.

In the South American lungfish (*Lepidosiren*), and in that more recently found in Africa (*Protopterus*), the air-bladder becomes lunglike in front and saclike in the rear, is divided into two distinct parts, and has the complete circulation of any other lung, *the heart sending the unaërated blood* to it by a

special tube, and the lung sending it back *by another*.

Perhaps before passing it should be mentioned that all these lungfishes continue to breathe by gills also, using one or both methods, as they may desire.

Here, then, is the growth (or evolution) of the lung within the fishes to a state of as great completion as is found in some amphibians and many reptiles, where also it has cells in front and is a sac behind, in which the air may be simply stored. Even so far up as the birds, where the lung is single, the whole body (bones, etc.) is often full of air-spaces intended to assist a rather scant breathing surface.

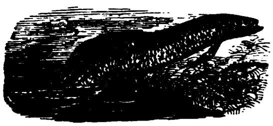

FIG. 57.—Lepidosiren.

The author has tried to present a glimpse of what a single organ may hint of its own development. If his conclusions are wrong, sufficient facts are given for you to form conclusions of your own. To his own mind it seems not improbable that the air-bladder arose as a simple storage sac attached to the digestive tract; or perhaps it originated as a simple aërating organ of its own kind, as much so as a gill. It is shown as it develops in the young fish to be formed out of a pocket of the gullet; so, likewise, the lungs begin to grow in all the air-breathers. That it is the forefather of the lung there can be little doubt to the student.

It is not at all improbable that in the forefathers of the modern fishes the air-bladder may have run in structure far up toward a lung before it began de-

grading toward the mere closed sac of the highest fishes. The author really thinks this is the case, because there is so much else to show that all our fishes tended more toward being air-breathing or land-haunting creatures formerly than any do now, except, of course, the lungfishes (*Dipnoi*).

Wherever we find a degraded lung, a part of it has become saclike, as in the serpents and in some

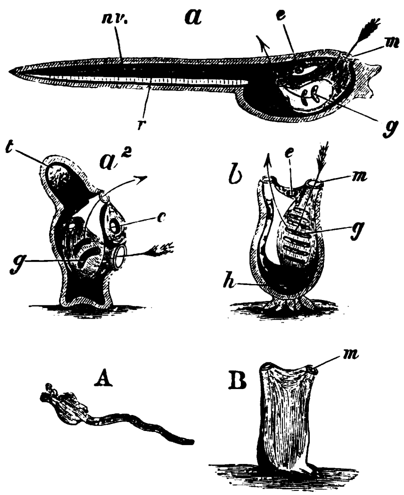

FIG. 58.—Diagram of the growth of a Sea-Squirt or Ascidian. A a, Young free-swimming stage. a², intermediate stage when first settling down. B b, Full-grown Sea-Squirt, rooted to the sea-bottom and incapable of movement. *m*, mouth; *e*, hollow brain with eye; *g*, gill slits; *h*, heart: *r*, rod of gristle in free-swimming form; *nv*, nerve cord in same; *t*, tail in process of absorption in intermediate form.

other creatures. We know that serpents once had more perfect lungs than they now have.

But the point of separation where the lung first started landward, dragging the gill with it, as in these lungfishes and the amphibians, was doubtless away down below the place where any of our true fishes are found to-day; but it was likely some distance up after the air-bladder was well formed; perhaps after it was lunglike and, as is hinted, after the fins had become rather leglike. Even the lamprey-forms and lancelet show evidences of having once been "better off"; and below them all are some creatures still (the *Ascidians*) which show in their youth that they began to have something like a backbone and were shaped for moving around, but lost all means of moving in old age by means of disuse or pure laziness.

Of course, you are aware that the air-bladders of codfishes are pickled, as something nice to eat, and are called "sounds," and that isinglass (not mica) is made from them.

In one instance the air-bladder is said to have been converted into bone.

TALK XIV.

How some fishes spend their winter and summer vacations at home if they choose, and how others travel for health and comfort; or hibernation, migration, etc.

Just here, immediately after respiration, it is proper to speak of a class of fishes usually called amphibious—that is, literally having double life. The term generally means that the fishes so named can live in two elements, as can the amphibians, such as the frogs, the salamanders, etc.

Since amphibious fishes usually show their ability to live in either air or water as they travel around, the topic comes in here very appropriately.

The most noted of these, because of their very peculiar good fortune in having both gills and lungs, are the lungfishes just discussed. While the bony parts of their fins are rather leglike, as we shall see under Skeleton, yet these are not at all stiff. In one case the limbs are mere threads (filaments). They use their lungs, quite likely, at that time of year only when the water gets foul or so thick and muddy that they can not breathe it by gills. They all live in hot regions where the pools dry up in summer, and this is but one of their special arrangements for fitting them to their surroundings.

So, likewise, although they have lungs, they have

one more gill fringe than our common fishes. Rather, we might say, the one that is useless in common fishes is useful in them, a fact in keeping with our theory that the higher fishes once breathed better and were probably warmer-blooded.

It seems strange that the fishes which are really the most amphibious and travel around by land are gill-breathers exclusively.

We have spoken of how the mudskippers (of which there are two kinds, see illustration, page 43, Fig. 21), walk around on their fins and chase their prey on land, and of the peculiar eyes and strong spiny paired fins which they have.

They have the gills also specially arranged, for it is found that the back part of the mouth is a great cavity (larger than usual), and that the surface of the gills here is large also. When on land they are said to keep the mouth closed and to be thus able to breathe by having this space around the gills filled with air.

They can stay out on land for hours, can leap great distances by the front fins, thus seeking and pursuing a sort of crablike creature of which they are very fond. When pursued they escape by skipping, and do not always flee to the water. One observer states that he had to shoot his specimens. Even while in the water these fishes sit much of the time with their heads out, the body only partially under. At such times the gill-covers work very slowly, because, quite likely, the large breathing surface does not require rapid action.

Just next akin to these are the gobies, which suck themselves down to rocks and stay out on land between tides, thus saving a journey. These also have a similar breathing arrangement, though it is not so large. Some of the blennies also, and others, can live in the air by similar means.

In most of these fishes there is an unusual amount of mucus about the gills, apparently to keep them from getting dry.

The climbing perch, so called (*Anabas* is the scientific name, see Fig. 20, page 42), is truly a

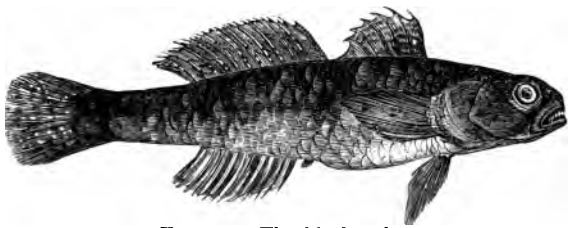

FIG. 59.—The black goby.

traveler, for it is found walking overland from one pool to another, being able, by means of these extra spaces around the gills, to emigrate thus.

It is said that at times it is found climbing up leaning palms, holding on by its spiny fins and by a special set of spines that project downward from the gill-covers. It is not known why it climbs the tree, though it has been suggested that it hopes to find water in the axils of the palm leaves.

In this fish these gill-surfaces are even more folded and wrinkled than in the others already noted, and the cavity for air extends well up into the head,

thus giving room for storage of air, and exposing a great area for aërating the blood.

There is another kind of gill-arrangement for this same purpose of air breathing, which is more extensive still. The folds of the breathing surfaces are not only greater in extent and the amount of wrinkling, but they run backward into a very deep pocket extending along the body. This arrangement is found at its best in a family of eels (known scientifically as *Symbranchidæ*), where it enables them to live for days outside the water.

In this case the sac seems yet to be simply a place to put the extra gill-surface in, and, of course, to hold the air breathed; but in an Indian fish, called *Amphipnous*, the gills are largely reduced and the sacs extend farther back still, and these are of themselves breathing organs—so much so that they really resemble lungs and open directly into the mouth, where their front ends are drawn up a little, as a purse. The circulation past these is the same as it is past the ordinary gills, and is not that of true lungs.

Now here seems to be a beginning on the part of Nature to make lungs out of gills. These sacs start directly out of the mouth without any windpipe, as also do the lungs of a frog. If we could not trace a much closer connection between the lungs and the air-bladder than there is between the lungs and these gill-sacs, which have lost their gills, we might err in thinking that perhaps Nature *had* built lungs in this way. But when we compare the structure of the lungfishes with that of the amphibians

above them and that of the other fishes below or near them, we readily see that the air-bladder is the forefather of the lung. The fishes that have these gill-sacs are not at all nearly akin; nor are they kin to the higher creatures which have true lungs, while the lungfishes certainly are. The former fishes are really high up in the bony-fish group—so far up that they could not be the forefathers of the true lung-breathers.

The manner in which both the lung and air-bladders originate (begin) in the little hatching fishes, shows that these two are of the same origin. Both commence as little sacs on the side of the gullet.

As we have seen, many fishes not specially supplied with large spaces or gill-sacs can remain long on land if the mucus is abundant or the region of the gills be kept moist. Such are the ordinary eels and others.

So likewise many can bury themselves in the wet sand, as the sand-cusk and sand-perch, and live there till the return of the tide.

Hibernation and Drying up.

Perhaps, before discussing how and why fishes travel, we may just here talk further of how some of them avoid moving altogether at the change of the seasons or the weather.

During the coldest weather some fishes are frozen into the solid ice. This may kill many of them, but some, as the carp, are said to revive when thawed out.

There are many fishes, among which is this same

carp, which bury themselves, at the approach of winter, deep in the mud of the bottoms, and thus lie dormant or asleep, as the higher animals hibernate. It would be useless to try to mention the number of hibernating fishes. They are all fresh-water fishes, mostly of our small streams, such as chubs, minnows, etc. Doubtless, when compelled by low water or extreme cold, many others do the same; and some of those that usually hibernate may remain active during some mild winters.

Such a very active fish as the black bass has been found buried asleep in the mud, even rather late in the spring.

Where the water is deep enough many fishes remain at home, and are active all winter. Sometimes these perish for want of air, if the pools are frozen over for long periods. Many a country boy has noticed the catfish coming for breath to a hole cut in the ice.

Some fishes that remain active cease to feed, while others, as the pickerels, are very greedy at this time, and are caught with hooks through holes in the ice.

A few fishes can not endure cold of a few degrees below the usual temperature, and must hasten away to deep or southern waters, where the temperature always remains much the same.

Before we leave this topic we must speak of how much heat also a fish can endure, for they vary greatly in this respect also. Thus it is well known that the brook-trout can not live in water above a certain temperature. The author has watched them as they

advanced higher and higher up the mountain brooks in the late hot summer, till they lay almost under the melting snow. Catfish, on the contrary, can live in water disagreeably warm to the human hand.

In the sea, also, certain fishes are either arctic or tropical, just as are certain birds and quadrupeds. But because at great depths of the sea the temperature is nearly alike everywhere, there is not so much difference in this respect in marine (sea) fishes as in birds, etc.

Most fishes are comfortable at our summer heat. Some extreme cases are noted. Fishes have been found in hot springs at a temperature of 120° F.—too hot to hold the hand in comfortably—and Humboldt makes the extravagant statement that he saw fishes thrown up alive and unhurt from volcanoes when the issuing water lacked only two degrees of being boiling hot.

In climates where the long, intense, rainless summers dry up the pools, we have seen that certain amphibious fishes can move overland to new pools. But Nature again has here provided a way for some fishes to spend the summer vacation at home if they choose. Thus in that remarkable group, the lungfishes, and in some catfish-forms, serpent heads, and others, there is a peculiar habit of burying themselves in the mud, which, in connection with their mucus, forms a sort of plaster or cement ball around them, in which they go to sleep till the rains come again.

Thus a lungfish (called *Protopterus*), found in Asia and Africa, so completely slimes a ball of mud

around it that it may live thus for more than one season—perhaps many; it has been dug up and sent to England, still inclosed in its round mud case, and when it was placed in warm water it awoke as well as ever.

This remarkable manner of spending the summer is called "æstivation," in distinction from "hibernation." One means simply the act of spending the summer, and the other the act of spending the winter, but we usually associate the idea of a sort of sleep with each of the words. This sleep, however, may be deep or scarcely sleep at all, according to the creature and the degree of cold or heat.

Fish and Weather.

This activity of fishes at the change of the seasons is seen in a much milder form at certain changes of the weather. Every one that has studied fishes must have noticed how much more active than usual they are while it rains; even those in deep water become playful, as if they were delighted at it. Indeed, it is likely that they are, since every rain may mean a flood, and a flood means new fields open for hunting—the hope of new food, and a new journey.

All creatures, even children, often appear to rejoice before a storm, or they are at least stimulated by the condition of the air that goes before storms. Likewise fishes, though they may lie deep on the bottoms of streams, feel the coming storm, being influenced by the so-called "electrical conditions of the air." Ground fish, as eels, flatfish, etc., are espe-

cially affected in this way, and are said to be much excited by thunder—quite likely by the jar of the earth. It is said also that if currents of electricity are passed through water, the fish appear very much alarmed.

Migration.

For the great yearly movements of fishes we may find doubtless more than one cause.

As noticed, one reason may be that they wish to escape the cold. Some fishes, as some birds, flee southward or to warmer or deeper water, even before there is a hint of winter. With many a particular kind of food which they find in the summer home may depart, and they either follow it or search for other kinds farther away.

It is highly probable that such fishes as the salmon family, the herrings, shads, pickerels, and many others which are so well known to come up the smaller streams in the spring to lay their eggs, originally had their permanent homes in the upper ends of these streams.

It may be that as they increased in number, and food (consequently) became scarce, they had to migrate lower down the streams; and they thus finally came to remain in the ocean or large, deep rivers. But, as in the case of the birds, there is a yearly return to safe places to rear their young, up where the water is cool, clear and running. There is, indeed, no reason to doubt that a sort of home feeling may exist among these fishes.

At such seasons some, as the salmons, make journeys of hundreds of miles—possibly thousands—to their usual spawning places. As they ascend the rivers they crowd over each other pell-mell, and leap up over falls and other obstructions, often as high as fourteen feet. Here they may pile up into great masses as they try again and again to ascend. They do not stop for food, rest, or safety. As they pass the shallow or narrow places, they may be captured in the simplest manner. Even bears are known to sit beside streams and throw the fish out of the water with their paws; and foxes snatch them up.

In our more common inland streams, the suckers, buffaloes, and many others come up in the spring, in great numbers, and spend the summer. Usually, however, these great pell-mell migrations are made by fishes which afterward go back to the sea or rivers as soon as the terrible egg-laying business is over.

The sea-fishes show this habit in the great shoals which gather and come near the shore year after year at nearly the same dates. Some morning the fishermen awake and find the coast waters alive with fishes. Often they disappear as suddenly as they came—at times so mysteriously that it is not known definitely where many of these shoal fishes spend the rest of their time.

These movements are not all connected with spawning, though some of them may be. A portion of these fishes are known to spawn in the open sea. It may be, however, that they once had a more permanent home near the coast, where they laid their

eggs, at certain seasons, and still the old instinct of travel comes upon them. It is rather evident that all fishes began to exist first near the shore. The author believes that there is in the human race even an old wild desire to move in the spring and fall, an inheritance from our savage ancestors when they roamed the hills and valleys for food and shelter, as the changes of seasons drove them about in the long ago.

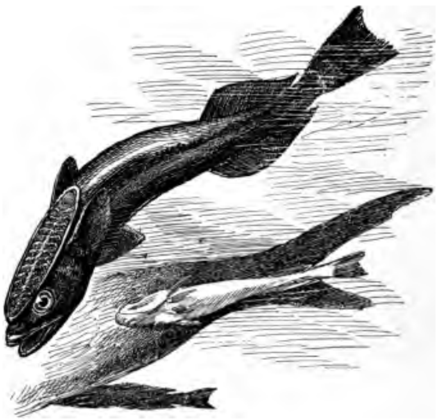
FIG. 60.—Remoras and shark.

Many of these shoaling fishes which do not spawn near shore approach it, because they are following and feeding on some others which come at this time for egg-laying. Such times are also the fishermen's opportunity.

In discussing how fishes travel we must not omit the cases of the *Remoras*, or suckfishes, which are well known to fasten themselves (by means of a sucking disk on top of their heads) to sharks and other good swimmers, thus getting "free transportation." Other similar cases will come up under parasitic fishes.

TALK XV.

What place a fish may hail from and where is its home when it has any; or distribution, home, and haunt.

Distribution.

How the various kinds of fishes are scattered over the globe—that is, where this family is found, and where that sort is plentiful—is too large a topic for our little book; but we can say *something* about it.

It is evident from many things that fishes have migrated far away from the place where they were first formed. Something of this can be seen from their structure, the shape of the young, etc., but we are not going into that now. We may note this: that the rocks show us by their fossils that some fishes which are tropical forms now, lived much nearer the north pole in the long ago; and that some now living mostly in the sea, as the salmons, have gone there from the fresh water and from much colder waters; hence they are likely of arctic or northern origin.

These same rocks, however, seem to say rather plainly that the sea was the home of all the early fishes, and hence there must have been, at first, a migration into the fresh waters. The sea was doubtless the original birthplace of all life from the fishes backward.

Now, however, some sea-fishes die at once in fresh water. Thus the shanny can live long out of salt water, but dies quickly if placed in *fresh* water. The case is the same with many fresh-water fishes put into the sea.

It is found that water enters into the tissues (muscles, skin, and other soft parts) of fishes—even into the blood. Salt water is thus especially searching, and to many fresh-water fishes it is quickly fatal.

As a rule (with exceptions) the fishes that are widely spread over the globe belong to very old families.

In the inland streams there may be local distributions of fishes that are more curious than those of the ocean, since there a continuous highway is always found. The tendency to explore new regions at flood times, which has been noted, accounts for many mysterious and sudden appearances of fishes in newly made ponds. The little sunfishes are especially apt to be on hand soon after a new pool is formed.

The author has met this little fish, not three inches long, skipping, by its tail strokes, along on its side, making very good time up stream, in water not a fourth of an inch deep. When it came to water deep enough it turned up edgewise, but lay over on its side again when a shallow place was found.

Sometimes these fishes are thus found far out of the beds of streams, when all the ground has been flooded with a sudden dash of rain. At times the rain ceases so suddenly that the fishes are left there, and thought-

less persons have found them and believed that "it had rained fish."

It is not improbable at all that tornadoes may take up fishes as well as other things and carry them to great distances, or that at least fish-eggs may not be thus carried. But it is by no means always necessary to think that it has rained things when we can not see how they got into certain places. The author once dumped a bucket of small catfish into a neighbor's pond, and was informed a year later that fishes had been rained into it.

It is possible also that fish-eggs may pass unhurt through the digestive tracts of birds, or that in their slimy stringy jellylike covering may stick to the feet of swimming or wading birds, and be dropped into new pools. In many cases the spawn of fishes shows great ability to live long in unfavorable surroundings.

Some of these methods may account for fishes being found above very high falls, though, in a few cases, it is more likely that the fishes were up there before the falls were there. Then, too, in times of great floods, some may have come overland from another stream on another slope, and entered this stream from the top above the falls.

The little sunfish noted was only a mile north of the crest between the slopes of the Missouri and the Mississippi Rivers. It had rained hard all that warm April day; and since only a short, flat strip of prairie, not a fourth of a mile wide, lay between the ends of this little branch and another that ran south into the

Missouri, the little skipper may have actually made its way into the waters of another great river.

In the Rocky Mountains there are many places where, by similar means, a fish from the Atlantic slope may easily pass into the waters of the Pacific; and thus we might account for some very similar fishes being found on both edges of our continent.

Home and Haunt.

This brings us more directly to the consideration of the homes and haunts of the fishes. Necessarily, in talking of peculiarities of structure, a great deal of this has already come out. Thus in the fins, shape, tail, barbels, lungs, gills, air-bladders, teeth, etc., the bottom-liers and surface swimmers, walkers, climbers, fliers, sleepers, and so on have shown themselves. Likewise in the topics that are to follow, such as feeding, spawning, nesting, capture, etc., much more of it will be noted.

But many fishes are found in regions from which they stray short distances only, except at certain seasons. These regions may be truly called their homes. In these homes they have definite places where they lie, hide, or play most of the time. These are their haunts.

In general we say that fishes are of the sea (marine) or of the fresh water. Those in the sea may be nearly always near the shore (littoral), or they are found mostly in mid-ocean (pelagic). They may be surface-swimmers or deep-sea swimmers. They may be ground-fish in the shallow sea, or swimmers in the

very, very deep sea. As in fresh-water fishes, their homes may be indicated by the continents near whose coasts they live.

Fresh-water swimmers also have their homes indicated by the continents they inhabit, by the portions of the continent they are found in, or the special river in which they live. Their home, then, is much the same as their distribution. Altitude seems to stop a fish's progress rather quickly—much more so than the same amount of cold does when found in the direction of the arctic regions. It may be caused possibly by the thinness of the air. Perhaps the usual dash of the mountain streams is discouraging to many. At any rate, only those vigorous lovers of cool water and plashing waterfall—the salmon-folk seem to take largely to streams at great altitudes. Even in summer these do not care to go too high; quite likely on account of the coolness of the water. An old trout fisher in the Rocky Mountains will dip his hand into the water and say that it is "not worth while to fish up any higher; the water is too icy."

The haunts of fishes are more definite, and, quite likely to us, more interesting. These may be in the places where they hide from foe, where they lie concealed from their prey, or the place where they digest their food, rest, and sleep.

Our little sunfish hides beneath overhanging weeds and grasses—that is, if the water be clear. Rocks, brush, the sides of logs, projecting banks—anything that conceals or protects may hide a fish. The roots of trees overhanging the banks is a favorite lair for

our black bass of the inland streams. From this he darts out often, making a great wave of the water, at some minnow that is passing by. Likewise drifts furnish a good hiding place. These are much used by the large catfish of our creeks, and if there be a scum dammed in to a sort of up-stream canopy, above the drift, the place is especially attractive.

Many large fishes depend simply upon the safety that deep water affords—rarely venturing out of it, because the shallows expose them greatly. For this reason shallow places and small inlets, where little branches come in, are favorite haunts of the minnow, shiners, chubs, and other small fishes, for here the large fish will not pursue them. Likewise under the shadows of steep banks, certain fishes, as our crappies and others, lie in companies, and pounce in packs, as wolves, upon anything eatable that passes.

Often a fish has one haunt where it feeds and another where it rests from its labors—a business place and a home. Thus brook-trouts are apt to lie in shallow eddies just below little falls, so that anything that floats down may make a circle or two, giving a good chance for examination and capture. Afterward they often go to the deep, calm pools and lie lazily near or on the bottom, while digesting their food.

The rapid ripple, in which the water is so constantly disturbed that an enemy from above can not see into it, makes a good hiding place for some strong swimmers, but they must go out of this occasionally and rest. The author has seen a mountain trout

appear to remain perfectly still in a current that would sweep an elephant off its feet.

As already mentioned, there are some of the shoal fishes of whose homes, after they leave the shore, we know very little or nothing. So others roam the surface in a constant aimless search, having a haunt anywhere that a prospect of food is offered. Thus sharks may cross the ocean with vessels, to get what may be thrown overboard, and the little pilot fish may follow likewise for the crumbs that fall from its larger friend's table. These and others can be said to keep house upon or near the surface.

But there are in the ocean many special haunts of fishes—too many for our space. Shells, rocks, seaweeds, caverns, and nooks innumerable offer hiding places. Some little fishes find traveling homes in floating masses of seaweed, with which their colors may so blend or their tentacles or bartels so twine as to render the body scarcely noticeable.

There comes in here also the mention again of those deep-sea fishes which show by their structure and kinship that they—their forefathers rather—once lived more nearly to the surface than at the bottom. No one of them belongs to a peculiar family of its own. They are many of them eel-forms, and some of them have near relatives, as the sharks, swimming yet high above them.

It is very evident that fishes have often changed, not only their homes, as we saw under Distribution, but their haunts as well; and with change of haunt and habit has come change of structure. That is the

reason the author wishes you to be a little patient with the structure of the parts of fishes; for these finny folk, as well as people, often tell, without meaning it, where they have lived. We frequently know that a man is from Maine, Massachusetts, Missouri, or Mississippi by his use of words and his tones. So if we study fishes they may speak out through fin, tail, barbel, etc., whence they have come, and what they have been or are now doing. We may say to them as was said to Simon Peter: "We know thou art a Galilean; thy speech bewrayeth thee."

Many fishes make their homes in underground streams and in caves. Some of these become totally blind, because in their haunts they have little use for eyes. Well-known instances are found in the Mammoth Cave of Kentucky and other caves of our own country, and in the caves of Cuba.

Parasitic Fishes.

Besides simply hiding among sponges, corals, and other living animals of the sea, some few fishes live close about the mouth of sea-anemones, starfishes, etc., where they may not only hide among the feelers or fringed tentacles of their hosts, but may share the food which is drifted that way or drawn in at the mouth. There have been rather romantic statements made that, at the approach of an enemy of the true fish, these feelers of the host close around the guest and protect it; but it is to be feared that considerable salt had better be sprinkled over that fish-story.

Other little fishes have been more impudent and

daring still, and have made their homes within the mouths of other fishes. In that great space that is in the back part of the mouth (pharynx) of the angler or fishing-frog—something like that which belongs to the amphibious fishes—it is said that a little fish is often found living comfortably. Here what comes to the angler's mill is grist to the little guest.

Likewise other instances of this kind have been noted, until there is much doubt cast upon the statement that certain fishes carry their young about in their mouths, since the so-called young may be little parasites. This latter is an equally interesting habit, however—in fact, quite human; for so many of us take better care of other grown folk that come to see us than we do of our own children. We little people know how that is: "Now, dear, you run away and wait till mamma's company has eaten."

Beyond all this a certain eel-form is known to live in the stomach and breathing places of the so-called sea-cucumber (*Holothuria*), and even inside of the shells of mollusks. The most usual one is called *Fierasfer*. (See Fig. 18, p. 36.) It depends, of course, solely upon its host for food.

Homing Instinct.

While this topic was mentioned under Migration, perhaps there is no better place than this to state that fishes, as well as other creatures, show a love for their haunts or homes and have that mysterious ability to return to them quickly. In the cases of such as live in small streams or even rivers, the shape of the

bottom and banks, or the direction of the current, may guide them. Dr. Abbott mentions that he took a fish away from its home some distance, and when he ran quickly back to the place, it was already there ahead of him.

In this case the fish may not have been taken beyond its usual range, and perhaps knew the way. But in those shoaling fishes that go great journeys through the sea and come back, without sight of land, to the same place so accurately, there is some sort of guiding sense which is not so easily explained. They doubtless have a remarkable sense of direction and a remarkable memory of the changes of direction that have been made, as well as an accurate idea of the distance traveled each way. The story that the directions of waves, currents, stars, etc., guide them is scarcely to be credited. Like every other sense, this is doubtless more complete in an old fish than in a young one, and is therefore greatly improved by experience—as this same faculty is cultivated in a homing pigeon; but it is an extra power of some kind which the acutest senses of man, unaided by special instruments, can not compete with or even approach.

A fish, unlike a bird, can not look far around it, which fact excludes all chance of guidance by surroundings.

TALK XVI.

Why a fish may love its fellows, and how it may win a mate and bring up its children; or, shoaling, courting, nesting, spawning, care of young, etc.

WHY these migrating fishes are thus crowded into such great shoals is a question not easily answered. Little fishes in small groups are frequently seen to follow each other blindly in their movements. Possibly one of them only will see an object and dart at or flee from it, when, without any hesitation, all the others try to do exactly the same thing. This habit puts the senses of every fish at the command or use of every other one, and may really be of great help. The mere feeling of safety in the presence of others, or the fact that misery loves company, may be the first instinct that moves all free creatures to collect together.

In those fishes which pursue others it is quite helpful to go in flocks, as wolves pursue prey in packs. If the prey rush from one it may fall to the other. Thus it is often noticed that flying fishes even, when frightened by one fish, may fall into the open jaws of another, since these pursuers follow them in great spreading companies.

It may be that it is no advantage now to the small fishes pursued to be crowded together; in fact, it

would seem to be a great disadvantage, since so many more can be captured at a gulp or a dash. But it is possible that in the pursuit of their own prey this crowding is of great advantage. Possibly if not a help now, it may have been helpful at one time to their forefathers, and it is now kept up as a habit which they have not yet changed. Many useless habits now are vestiges (left-over things) of some which were useful long ago, when the family customs or the surroundings generally were different; just as we human folk wear rings in our ears and on our fingers and birds on our hats, because some savage ancestor ages ago had the habit of doing so.

There can be no doubt that these groupings are selfish, yet the constant association may build here, as among the higher creatures, a sort of love for a fellow-traveler or fellow-hunter.

Affections of Fishes.

But the more fellowlike feeling between fishes is not developed so much in this way as it is in a few cases between the two parents, or between parent and children.

In most instances, however, there seems to be (in fact, according to their habits, there can not help but be) a total lack of affection between the two parents or between parent and young. Often the female goes to the spawning place far ahead of the male, and they never see each other unless by accident. She deposits her eggs and goes away, and the male finds these eggs only to call forth his attention. Over

them he deposits his milt—a fluid necessary to make them hatch—and away he goes also, leaving the little fish an orphan.

In some other cases the parents go paired, side by side, to their spawning grounds, remaining very near each other while there, and it is thought by many students that they remain paired ever after.

Of course, in those fishes, noted hereinafter, which have their eggs hatched within the body, a much more intimate association must exist between the parents. Between these comminglings and those where there is no meeting at all there are all grades of association, some of which are not yet well understood.

Sex.

There are found in all fishes, no matter what the sex, rather high up in the body-cavity, two long, yellow, fatty bodies. That of the female is called the roe, and may, in bony fishes, be often told from that of the male by being simply a long sac filled with little shotlike balls, which are the eggs.

At times, however, it is impossible to tell one sex from the other. It is stated also that a few fishes have both kinds of bodies in them, and are hence both male and female. But this is very rare.

Just before the spawning season this sac grows very large, and is often worth more for food than the fish itself. At the proper time this sac bursts and the eggs are laid. Sometimes there is a special tube by which they leave the sac, and sometimes they drop into the body cavity and simply run out.

Eggs.

The eggs of even our bony fishes are not all of the same size, though they are usually round like a ball. As a rule, the larger the eggs the fewer there are of them. In the bony fishes the number may be millions from a single mother at one spawning. It seems to be rather a rule with Nature that creatures which have many enemies (either of eggs, the young, or the adult) lay many eggs.

The eggs of the shark-forms are not round, but are often pillow-shaped, with little strings or tendrils at each of the four corners. These latter may twine around anything, as sea-weed, and thus anchor the egg till it hatches. These eggs are usually covered with a sort of horny or leathery shell, while the eggs of the ordinary fishes are soft, with their skin (membrane) only around them.

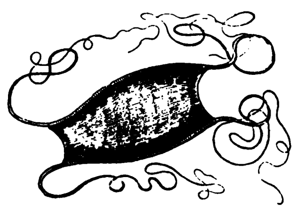

FIG. 61.—Egg of Skate.

This great difference in the eggs of fishes is quite interesting and peculiar. It is remarkable that in those low fishes, the lamprey-forms, the true lampreys have eggs that are small and soft, while in the hag-fishes they are large, horny, and in many respects quite like those of the sharks.

So the split-up over eggs must have started low down in the fishes.

The eggs of the bony fishes may be placed almost

anywhere. Often they float upon the surface in long, stringy, flat bands or masses. Those of the angler are said to lie as a pink band of jelly, a foot wide and forty feet long, floating upon the ocean. Sometimes these masses lie on the sand, or the eggs may be scattered singly around here and there, anywhere, on the bottom.

Nests.

Many fishes, as noted, have special shores, sand banks, or other places, where they go to spawn, just as some birds have special nesting places (rookeries). We have seen how they go thousands of miles to reach these places. The salmon seems to think of the place where it was born, and feels that it would like to go back and bring its babes up in the old home region.

Other fishes dig holes to place their eggs in, as the toadfishes and the catfishes of our inland streams.

Among the true nest-builders, the various members of the stickleback family are usually quoted and figured; but the habit is by no means confined to these. In some miller's-thumbs (many of which are found on our northern borders), some lumpsuckers of the sea, and some serpent-heads of Africa, a nest is often built by the males. Some of the wrasses, those thick-lipped and parrot-mouthed folk, heap up nests out of seaweed, shells, and any convenient material.

In some of the common little chubs of our creeks, there is the habit of heaping a pile of pebbles, upon the first layer of which eggs are laid; then more pebbles and more eggs, till quite a little mound is formed. In those regions where the word "tote" is used when

"carry" or "convey" is meant, the author has heard these little fishes called "stone-toters" by the rural folk, because, likely, of this peculiar habit. The name more properly belongs to one of the suckers.

Our little sunfishes build nests that are mere shallow cups scooped in the bottom, but they are homes to these little folk, and they fight for them bravely. They are often social in their nesting, as are many birds—that is, they nest near to each other, and have paths and byways leading in among the growing plants on the bottom, like those of the field mice and the hares. Many other fishes, too many to notice, build this sort of nest—a mere depression.

Some of the cousins of the angler—one especially, known only by its scientific name as *Antennarius*, belonging to the same family as the frogfishes and mousefish—seem to sew bits of seaweed together into a little nest in which they put their eggs. This is attached to a floating home of seaweed in which the fish lives, and the nest here is more a cradle than a house. In this case the threads are made of a sort of mucus spun out as fine as spider webs, and often there seems to be more of this than there is of the weeds.

As there is one bird, the Chinese swift, whose nest is all glue or cement, so there is one fish that has this kind of nest. In this case the male is said to pick up the eggs and blow them from his mouth along with a lot of mucus bubbles. These bunch together, as bubbles in soapy water do so beautifully, and, hardening or drying, form a light, floating nest, one of the neatest things in Nature—a little, unsinkable ark,

in which this father sends out his babes into the world.

While others lay their eggs for safety in holes already made, in crevices of rocks, or between and

FIG. 62.—Antennarius and nest.

under stones, or simply in masses of seaweed and other things, there are many that never even seem to come near shore or shallow water or other safe places

to spawn, but drop their eggs anywhere in mid-ocean. Thus mackerel are known to spawn at sea, and the young of many other fishes are found so far out from shore that they must have been hatched in mid-ocean. A few fishes spawn in winter.

Care of Young.

While, as we noticed, so many fishes are careless about their young, we find a few, such as these nest-builders, who seem thoughtful, and there are some other very striking cases where the eggs and the young are cared for.

We have noticed that some fishes fight for the defense of their nests, and the sticklebacks and sunfish, black bass, and others, are noted for staying by their eggs. In this case it is usually the male which battles, though in most bony fishes the female is larger and better able to fight; but she so often seems an unnatural mother, not only *not* caring for her eggs, but really wishing to eat them. Mr. Darwin notes that one Old-World stickleback has to fight his mate almost constantly to prevent this.

In only a few cases does the mother take charge of the young, but some of these are so peculiar as to deserve notice, especially among certain catfishes. Even in those of our creeks a little close watching will show a parent—said to be the father—swimming directly beneath the young, which, like a dark shadow, seem to float upon the surface of the water, usually late in the hot summer afternoon. In another branch of the family the mother, at the time when her eggs

are laid, has the lower part of her body softened and made jellylike or spongy. This she presses down upon the eggs, and they stick to her and finally become fastened by a little capsule having a stem growing out from her around each one of them. When they hatch, the little fish bursts out of these capsules. Another kind of catfish has folds or wrinkles of skin below in which the eggs lodge. This is likely a development from the other peculiarity, as we shall see is the case in another family.

In the pipefishes and their near kin, with tubular mouths, tufted gills, and curling tails, you remember, there is found something very similar to this last case. Here the spongy flesh is evidently the beginning of something higher. In another case (the only instance in the family, it is said, where the female is concerned) there is a sort of pocket, formed evidently by the growing together of the ventral fins, in which the eggs are carried and hatched. In all the others it is the male solely that has pouches, and in them these pouches are much better or deeper than in the female noted, and they often extend from the tail up to the throat, and are drawn in a little, like the old-fashioned purse, to keep the little fishes from getting out too soon. When the father thinks it time for the young to depart, he stands rather erect in the water (the usual position even in swimming), and, scraping himself downward past the edge of a rock, shell, or something else, he forces the little fellows out into the world to shift for themselves. See picture, Fig. 24, on page 48, of a sea-horse in the act of doing this.

The female is said to place these eggs in the pouch of the male. It has even been claimed that a peculiar mucus or fluid is secreted in these pockets of

FIG. 63.—Stickleback and nest.

the sea horse, which, for a while, forms the food of the little fishes, much as a sort of milk is secreted in the crops of pigeons with which they feed their young.

There can be little doubt that in some such way in the pouched mammals, as the opossum group, the habit of furnishing milk to the young began. Nature is a great hinter of better things that she is going to do after a while—a comforting sort of thought to those who hope and trust.

In another South American catfish (or one belonging to the great catfish family, perhaps the most widely distributed fresh-water fishes known) the father takes the eggs in his mouth, carries them about, and they are hatched and live for a while in his broad, deep pharynx or gill cavity. You recall that some fishes were found parasitically boarding here, which are not the children, and that some doubts have been cast upon this fatherly habit. But others—one in India—do the same thing, and a certain fish in the Sea of Galilee is said to carry the eggs in its mouth. There is no record of the young running into the parent's mouth to escape enemies, as some of the little snakes are said to do.

In the low fishes, as the sharks and sturgeons, there is no care of the young known, and in most cases the little ones are orphans always, dodging around to escape the jaws of something larger—often those of their own parents. In no class of animals are there so many that prey upon each other as in the fishes.

Play and Display.

This topic is suggested not by fishes caring for young, but for each other. We have already noticed how they may go in shoals when grown, or in schools

when young, and thus grow perhaps to like each other, though some of these, as our catfishes which play in troops when little, become solitary and selfish when they get very large.

There can be little doubt that fishes play. As is usual with animals, this may consist largely of mock fights, chases, and retreats, which things show how a fish can see a joke and take one. It implies a sense of humor—a sense which every human is not largely endowed with.

Little fishes, apparently in pure glee, sometimes leap entirely out of the water. Play here, as with children, seems to take on the art of pleasing, as it does in all animals. Who has not seen a dog trying to coax another into good humor by play?

But play for pleasing may take on the form of *dis*play—the wrong sort of play which so many of us, not scaly or finny, indulge in. We have already seen, under "Color," that at the social seasons certain ornaments and brilliant markings may appear, and it is undoubtedly true that our little aquatic friend is found at times showing off in a very earnest yet undignified manner, either to charm his sweetheart or to make his rival feel bad. You know we all use our pretty things in these two ways, and it is to be recorded to our shame that we often enjoy the one as much as the other, having become no better than the fishes in this respect.

We have noted that the nest is usually or often built by the male. He has been seen, after its completion, to go to a certain finny lass which he doubt-

less preferred above all others, and, by showing her all his "beauty spots," by dancing, turning, and running in and out of the nest, to offer her, along with his devoted heart, a home already fitted up—a thing that is often very fetching among us human folk.

After the proper degree of hesitation and modesty, she accepts by going into the nest, when the little lover's joy seems to know no bounds, and doubtless his little cold-blooded heart is warmer a degree or so.

It is certain that many of these fishes remain paired for a season or two, perhaps for life; but at each season it is quite likely—or at each anniversary of their marriage rather, as is well known to be the case with some birds—the husband insists on a silver or golden wedding that shall give him the chance and the pleasure of living over the romance of their first courtship. We human folk are not so much ahead of everything in everything.

Fishes are often spoken of as cold-blooded, unfeeling sort of creatures. Usually they may be; but we are growing of late to look for love and the root of all that is good in us in many of the things below us. God did not wait for man alone that love and sacrifice might live.

We have seen some wonderful instances of care of the young: "Greater love hath no man than this." An equal love for mates is often seen, though a fish, like a human, marries again if its mate be killed. Dr. Abbott says that he once killed the mate of a little fish and put the body into the nest; when the remaining one discovered the dead spouse its show of

grief was so great that he felt sure that he should never try the experiment again.

If the author wanted to use a big word he would say that he had just been talking to you a little about the psychology of the fishes. But he will have to let much of their common sense and smartness pass, except as you may note it in other topics. Usually, when not desperately in love or almost starved, a fish is not a fool by any means; and this is about as much as can be said of many of the rest of us.

There are fishes that thrust their heads above water and call or sing, doubtless either to attract or charm their mates. The rule is that such musical fishes are not very pretty. They presume more upon their accomplishments than upon their fine clothes.

TALK XVII.

What a fish may eat and how it may get it, and how it is hatched and gets its growth; or food, hatching, and growth.

A FISH eats much as any other creature does, and its food, by means of the digestive tract and the circulation, is carried to the various parts to build them up. After it is aërated, the blood carries with it the stimulus of the oxygen, so that the food is actually broken down, consumed, or burned in some way that we do not understand. This destruction of the food, or of the tissues that it has built, produces energy or force—somewhat as the destruction of the zinc in a battery produces electric force, or that of the coal under a boiler produces expanding force.

We must not feel, however, that the process is as simple as the examples given. That mysterious force called Life comes in here and makes this battery unlike any other battery, and this furnace and boiler unlike any other furnace and boiler.

The forces which are the result of the consumption of food are of two kinds in fishes and the higher creatures. The first is a nervous force, whose business is largely to set up and restrain again that other peculiar force known as muscle-pull.

Under the next topic we shall see, just a little, how these things are arranged.

As already noted, the hot-blooded animals convert more of their food into heat than the fishes do. The latter can doubtless convert part of the food into force without forming heat, just as some of them convert it into light without heat. We have seen, also, that they make electricity without heat.

As a rule, fishes are very greedy feeders—especially at certain seasons. As noticed in the codfishes, the liver seems to become a great storehouse of fat, a substance which in animals is another name for the best of fuel or force-maker.

But there are seasons when some fishes may fast for great periods and yet remain active. This is frequently noticed in the goldfish of the aquariums; and any angler knows that there are long periods when the fishes of fresh water do not appear to feed at all; then come other times when they "rise," or "bite" well.

It is a singular thing that some creatures can fast for long periods, if left undisturbed, and yet lose almost no appreciable weight. It is said that while fresh-water fishes may go for months without food, a few days of fasting kill the marine fishes.

As we have seen from a study of the stomach and teeth that fish are both flesh-eaters and vegetable-eaters, observation of their habits shows the same thing. The carps and others chew weeds, as do sheep and goats, while an angler will take down some living animal at a gulp. Others swallow the mud of the bottoms in great quantities, and allow their stomachs to separate out and digest the little food there is in

it, and reject the undigestible matter. They have thus no need of taste or teeth.

In the gizzard-shad the stomach has so much to do in the way of grinding food that Nature has thickened its walls into a gizzard—such as the vegetable-eating birds possess.

We have frequently had to refer to the kind of food a fish used, and the way it captured or ate it. Food-taking, the all-important thing in life, is associated with every form of structure, with every part of the body; and a slight review or general collection of some of the more striking feeding habits may not be out of place.

Fishes that feed by gnawing or scooping at the half-hardened parts of corals have teeth set for the purpose, or beaks shaped for cutting them up—beaks somewhat similar to those of such birds as the parrots, grosbeaks, etc. In these cases the fish often lives

FIG. 64.—The hagfish.

or hides among the branches of the coral, so that it finds here both home and pantry—bed and food.

We have noted such fishes as live inside of other creatures. The hagfish, however, first fastens itself

upon a fish by means of its sucking mouth and pistonlike tongue; and it finally, by means of a ring of teeth around this tongue, bores a round hole into its prey and enters the body. This eventually means death to the fish it fastens upon, but it is surprising how long some fishes can endure injury. Fishes with a sucking disk on top of the head do not feed upon the host; they simply catch on for a free ride, as boys hitch their sleds to a moving vehicle.

We have seen, of course, how most sharks seize their prey and cut it up; how rays fall on theirs at the bottom, and covering it with their great winglike fins, force it into their mouths. But the basking shark, among the largest of the sharks—and the most harmless—strains water out through its gills, where it has a set of special fringes to catch small particles of food as they pass. Its method of feeding must be very satisfactory, for it is often found floating on the surface, as if it were full and asleep. It has very small teeth. The mullets sift food similarly through their gills.

We have had frequently to mention the angler's habit of stirring up the mud around it, and moving its two colored tentacles above, so that a fish might think these were worms wriggling in the mud, and be lured to approach. This fact, it is said, was known to the ancient Greeks. A similar use is made of glowing (phosphorescent) barbels by some deep-sea fishes.

Besides the pursuing habits of the mud-skippers, and the leaps of the trouts and others after

prey which is not in the water, there is another well-known case, which is always interesting. It reaches up almost to human ingenuity.

Ornithologists have loaded their guns with mercury (quicksilver) to shoot specimens of humming birds. While the plumage is not injured, the liquid shot stuns the bird. Some of us know that a man may be killed with a stream of water from a hose, and mountains are moved in this way in mining.

A certain little fish, well called the fly-shooter, has a tubular mouth when it is closed; and when it sees an insect sitting on a weed or limb overhanging the water, it swims slyly up under and shoots out a little jet of water with such force and good aim that the prey falls stunned into the water, and is eaten before it can recover. These fishes live in the waters in India and the islands of Asia. They are brilliantly colored and beautifully marked, and make interesting pets in an aquarium. It is said that they can bring a fly down four or five feet away.

Often, after they are full, the fishes which kill their prey may keep on killing for the enjoyment of pure cruelty, just as dogs kill sheep or anything else, as a weasel will kill all the chickens in the coop, or as a boy or hunter will kill more birds, rabbits, or squirrels than he needs. But the comparisons are sufficient. Sometimes near the lair of a large bass, bits of minnows will be found floating, or a fisherman will find his minnow bitten in two, or mangled by a bass that is full but still in a killing mood.

While some fishes appear to reach a limit in

their growth which they never pass, others seem as if they are large or small in keeping with their length of life, and the amount of food they get. Thus a carp, like a hog, may be fed up to a great size in a short time, and if given all it can eat, there is scarcely any telling how large one might grow, for these fishes live a long time and grow, perhaps, as long as they live. But do what we may with a minnow, a darter, or a stickleback, we can rarely force it to grow beyond three inches.

How a Little Fish grows from the Egg.

Since growing is so largely the result of eating, it may not be out of place here to see how a little fish grows from the time it is deposited as an egg. Those little fishes that are born already hatched are not included in this account.

The eggs of fishes are hatched directly by the heat of the sun, or by heat absorbed from the water. So far as we know, there is no such thing as a fish sitting upon its eggs (incubating) to hatch them. This seems to be useless, since the body of the parent is no warmer usually than the water in which it swims, and it can therefore give no warmth to its eggs.

But some other cold-blooded creatures sit upon their eggs—perhaps only to guard them, but it may be to hasten their hatching. If this sitting (incubation) found its beginning in the act of remaining over the eggs to guard them—as it probably did—then this habit began at least as far down as the

fishes; for many of them stay over their eggs and guard them.

We shall omit all the difficult things about hatching, and note that the first very noticeable beginning of the fish is a little streak or string that lies over the outside of the yolk of the egg; for a fish's egg, as well as that of a bird, has a yolk. The fish begins in the white of the egg (so called in birds), but it finds most of its food in the yolk.

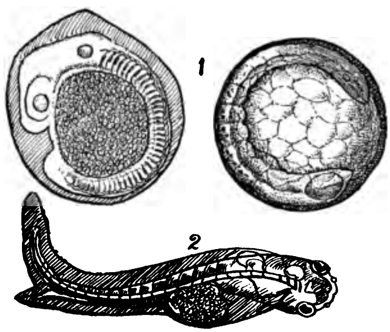

FIG. 65.—*1.* Fish eggs. *2.* Young fish.

About the seventh day—varying with the kind of fish and the amount of heat—the heart and the blood-vessels show as little red threads that run here and there, and these begin to beat as the blood is sent around to build up the body. A little later other internal parts begin to show.

The pectoral fins develop very early—doubtless because of their importance in balancing the little creature—and are very large for so small a fish. The eye at this time is simply enormous in proportion to the size of the body.

In about twelve days the baby fish breaks through the tough covering of skin or membrane which surrounds the egg, and goes swimming about with the

round yolk still hanging to its stomach. It is literally its bread basket (or nursing bottle placed a little low down), and from this its nourishment is drawn until it is able to catch food for itself. Usually this yolk remains for a period of seven to ten days, when it is gradually absorbed into the body, and the fish grows rapidly by food digested in its stomach.

Previous to this there was little need for the young fish to breathe because the egg furnished air as well as food; but now gills begin to develop or form, and by the time the lunch provided by the egg is gone the little swimmer is getting its breath in the usual way. In a few fishes these gills, as noted, are at first tufts on the outside, but they are afterward taken into the gill-cavities. Sometimes these external gills show while the fish is still in the egg, but are of the usual sort after hatching.

This same practice of being fed by the yolk for a while after being hatched is seen in such birds as run from the nest as soon as hatched—little chickens, for instance; and this is also the case with some other creatures: but in all these cases the yolk is drawn into the body *before* hatching.

TALK XVIII.

Where a fish wears its bones and how it moves them, and how it may not be so brainy now as it once was; or bones, muscles, nerves, and brain.

BACKBONE.

AFTER a series of talks about the more interesting subjects of homes, food, spawning, hatching, growth, etc., the author turns reluctantly to talk of a fish's bones, muscles, and nerves, or the system of locomotion. The discussion of some of these topics is necessary to our best understanding of other things that go before and follow this talk.

When speaking of scales and skin, it was said that before the fish-forms existed Nature built outside skeletons exclusively. As Professor Riley once said, to use the phrase of a great wit, some of them, as crawfish, lobsters, insects, etc., literally "sat in their bones" instead of their flesh. They wear their bones outside.

But when the fish-forms began to hint of their coming, it was done by means of a membranous, jellylike or gristly string which was found inside the flesh, just above the body cavity. In a few creatures below the fishes there are found bits of it, but such do not run the full length of the body—only half way, perhaps; still, they were the beginning of that

effective weapon for the conquest of the dry land which is known as the backbone.

The scientists call this original string the *notochord*.

Around this, at first apparently to protect it, there began to be formed other gristly parts, short and broken, which afterward became bony and jointed, as we see in the more perfect backbones of the fishes of the present day.

Even in the lancelet the original chord itself was broken up into a series of joints, which appeared as thin disks (as coins) placed face to face inside of a continuous, long, round sac that just covered them neatly, like a long, slim purse.

For a long time in the fishes this chord remained, wrapped only in a loose covering of membrane and in surrounding gristly pieces, the chord itself being the string on which these pieces were strung. It yet remains so in the lungfishes, the sturgeons, and many others. But at last, in the higher bony fishes, these gristly parts became so important that they closed in on the chord, and this latter has thus entirely disappeared or been replaced by bone, except when the fish is very young. In one kind of fish (the spookfish, see Fig. 99, page 249) a complete series of separate rings remains formed around the chord, much as a series of small silk spools might be strung on a string. In the sharks these rings have closed in more and more till they have become solid—at least solid gristle, and the original chord is cut up into small bits, lying between these bony rings.

We must not get this chord confused with the spinal marrow, which is really a part of the brain. This latter, a great nerve-chord, is older than the *noto-chord*, and lay separate above it for a long time; but when the hard, gristly parts and bones began to form in this region, they made a separate groove in themselves at first for this nerve-chord to lie in. Afterward this groove closed together on its top side, and we have that tube in which we find the marrow now.

So, likewise, we might as well say here, there were grooves (and later in some places tubes or round holes) below the *notochord* where certain blóod-vessels were carried.

The author has dwelt on this subject that you might have here a little glimpse of the probable origin of the backbone, because it is in the fishes proper that this first shows. We should be interested in an implement so great in animal progress and in the conquest of the world. There would probably never have been any skull, and therefore no brains, as we have them now, had the backbone never been started on its way by the very low fishes.

Of course, it is possible that great speed, intelligence, emotions, and affections may be developed without a spinal column, as they are to a large extent in some insects. If the other worlds, as the planet Mars, be inhabited, its most intelligent and spiritual creature may be an insect or some form of animal entirely unknown to and unimagined by us; but on earth, civilization is what it is to-day because this same spinal column has been the means (the only

possible means) of man's walking erect. There seems to be a special fitness in man having his hands free and his head the highest part of him, pointing away from the slime of his origin to something higher yet; and, in fact, it is impossible for us to conceive a form and arrangement of parts better fitted for the use of an intelligent soul than that of man, who, Scripture tells us, was made in the image of God.

SKULL.

The origin of the skull or brain case is not a topic simple enough for us to talk about, even if anything definite could be said. For a great while students have wrangled much over it. It quite likely grew out of that simple tendency which Nature shows in providing the groove and tube on the backbone to put the spinal marrow in; but whether the skull is an expanded joint of this backbone or a separate box grown to it, is not a settled question. There are some interesting things which point both ways, but they are too technical for us. We may note, however, that the *outside* bones of the head in the fishes are numerous and seem now to be skin-bones, so called—that is, they have grown directly out of the skin instead of passing through the gristly state, or being first connected with some other bone. (See Fig. 51, page 116.)

The lancelet, we noted, had no head, and the lamprey-forms have only a sort of skinny capsule for a skull, apparently stuck on to its *notochord*. We have seen enough to know that Nature can easily develop bones suddenly wherever they are needed,

and grow two or more together at times. Here she has done this, extending the skin bones down to the gristle bones of the head when she chooses.

It may be of interest to add that while in man and all other mammals the lower jaw joins the skull directly, and in lower creatures still there is a single bone between the jaw and head, there is in the fishes here a series of these bones; and their peculiar arrangement differs in the shark-forms and the bony fishes, whereby the groups may be generally distinguished.

Bones which in man (and the mammals) are found inside of the ear only, are found outside here in the fishes, and are used simply to swing the jawbone to the head.

VERTEBRÆ.

To return to the spinal column. The breaking up of the chord into joints (*vertebræ*) seems to have been a matter which Nature indulged in at her convenience, or rather at that of the creature. Some fishes have many more joints in the backbone than others, and the families are thus distinguished from each other. The snakes are usually lengthened out by giving them a lot of extra pieces in the backbone.

When Nature desires to make anything very yielding (flexible), and at the same time stiff and supporting, it is broken up into bits well fitted together, as we saw in the fin-rays of the lower fishes.

In some cases, as in the backbones of the birds especially, certain parts are stiffened by having several joints of the backbone grow together; but this is not the case in the fishes. Indeed, in the higher ani-

mals a great many bones are now grown together which were once separate, but in the fishes these fused bones are still free, for it was in or near the fishes that so many bones first began to exist. This makes the study of the bones of fishes of great interest.

But we are not going very far into the subject, for it is a study by itself.

SKELETON.

It may be well to say that much may be known about a fish from a glance at a single joint of its backbone. In the lower fishes the whole skeleton is mostly gristly, but in some of these and all the higher fishes it is bony, as we find it in the perch, mackerel, smelt, trout, etc. A singular thing is the number of spines that may project from the spinal column, as may be seen by the picture. (See Fig. 51, page 116.)

In each joint a spine may project on each side, as do the teeth of a double comb. To some extent spines project from all four of the sides.

It will be noticed in the cut (see Skeleton, Fig. 51, page 116) that at the points where the fin rays come in there is a series of short, thick spines that run inward from the base of the ray or fin spine till they point between the spines which are on the backbone. These floating spines help to form a sort of connection between the fins and the spinal column. In the fishes there are many connections thus attempted which are not complete—not nearly so complete as they are in the higher animals.

These projections from the backbone are used also for the immediate attachment of muscles and ribs. The backbone is called *spinal column*, because it has spines upon it.

Ribs did not seem to be needed at first in the lowest fishes, though there were gristly hints here and there of their coming, even in the lamprey-forms. In the sharks and sturgeons they are only yet mere beginnings, or short stumps of cartilage (gristle)—at least not so long as in the higher forms. But while ribs are of no use to a fish in breathing, they seemed to be of great use in some other respects, especially in building the body better for more rapid motion. We find them (in our throats sometimes) of great number and many shapes. Some of them are forked where they join the backbone; many are forked at the other end, and a few are forked at both ends. Some are fairly splintered at the outer end; and in two cases—that of that large cousin of the mackerels called the tunny, and in that queer beginning of the bony fishes called the *bichir*—there are *two* sets of ribs, one above the other. These fishes are not nearly akin, one being much higher than the other.

The ribs in fishes may reach the breastbone, as some of them do in the higher animals. This bone is small and unimportant here, however; sometimes it is wanting.

Before leaving the backbone, it is interesting to glance at the manner in which it terminates or runs out into a tail in different kinds of fishes. In all the low fishes, as sharks and sturgeons, the tip of the

spinal column turns up as the runner of a sleigh; and usually, instead of having the fin around it, the rays stick out from each edge. They are nearly always the longer below. The tail in this case runs entirely through the tail-fin.

There can be but little doubt that the first true fishes had a straight "tail-bone," but this also ran entirely through the fin, with the rays of about equal length on each side.

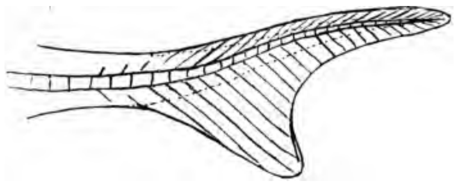

FIG. 66.—Structure of heterocercal or vertebrated tail-fin.

The bent-up tail-bones, as noted, are quite likely associated with early ground-feeding or low-swimming habits, when the stroke was more effective in paddling if the tail did not sweep the mud. This form is seen yet in the skeletons of sharks, and makes their tail-lobes all appear unequal, as we have noted in the thresher. (See Figs. 48 and 66.)

While, at first sight, this method of ending the tail-fin does not show in the bony fishes, there are yet traces of the *notochord* being bent up at the tip, even in those which are fully grown; and in the young and hatching ones the bend is very apparent (see Fig. 65, page 190), hinting that nearly all our modern fishes ascended from this style of forefather. Such is the tail of the bowfin, a fish

between the sturgeon-forms and the bony fishes. (See Fig. 81).

But in these bony fishes, however, the tail can not be said to pass through the tail-fin, but appears to have been much shortened.

Limbs.

We have been talking now about the central skeleton of a fish, but the limbs remain yet as the most interesting parts. We have seen much of them as we have come along; for we have already learned that the limbs of a fish are its paired fins.

In man and the higher creatures the limbs proper consist of three parts: a long bone next the body, two others in the middle, and the hand or foot, as the case may be, at the end. But in the fishes there is no trace of this first long bone, and often the others are very hard to recognize. As noted, the rays of the fins are in no sense fingers.

The manner of attaching the limbs to the body is also peculiar in the fishes. In man, and the mammals generally, the arms are rooted in the flesh, outside of the box of ribs, by means of three great bones which meet, and form the shoulder joint (or arch rather). In the lower fishes there is a similar arrangement, but in many of the higher ones the arms or pectoral fins are hinged to the head, the collar bone only being a part of the support.

The hind limbs of the mammals (and birds) are connected to bones that are now permanently fastened to the spinal column; but in the lower fishes

this joint also is simply rooted in the flesh, and lacks many of the parts found in the higher creatures.

We have noticed how these rear fins have traveled forward in many fishes, especially the higher. So, of course, their roots are farther forward, and in some cases they also are actually hinged to the head and to the same bones to which the fore-limbs hang —that is, the collar bone—as may be seen in the cut of the skeleton. (See Fig. 51, page 116.)

In a few cases the shoulder bones of the front fin run over to the top and join the top spines of the backbone. In no shark-form are the rear fins connected with the head. In all low fishes these fins remain well toward the rear, sending in bones or gristles that seem to reach for the backbone, but scarcely touch it, as the limbs of the higher creatures do.

This was doubtless the manner in which the limbs of all backboned creatures began—that is, first upon the surface. But there are a few things that tend to make us feel that all of our modern and many of our fossil fishes came from forefathers which had more leglike limbs than those we now find on the most of them. These modern limbs show signs of having *lost* some parts which may once have been used in walking or crawling "on all fours."

In the lungfishes we find what has been called by students the earliest form of fin, after the skin folds had been broken up into four parts. See Figs. 67 and 68, showing limbs of Australian lungfish.

It has the fins far apart, and running lengthwise through each is a bone—jointed as the backbone is

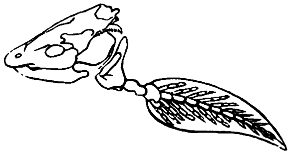

FIG. 67.—Head and fore limb of a Ceratodus.

FIG. 68.—Hind limb of same. (After Gunther.)

—but appearing decidedly more leglike than the usual fan-shaped fin. In this fish also the shoulder joint is more perfect than is usual. Much farther up in the fishes—in those having a true bony skeleton and no lungs but gills—there is the *bichir*, which also has a fin built on a similar plan. It seems strongly hinted that the early fishes may have wandered landward a little and come back to the water later, just as we are sure that whales, seals, and such animals were once land-walkers, but in the long ago they took again to swimming almost exclusively, and thus changed their shape to that which we now see.

You recall that the air-bladder, the circulation, the degenerate heart of the high fishes, and the forward movement of the rear limbs indicate that fishes once knew a better estate, from which they have fallen.

At this turning point it is possible that fishes went backward, and the amphibians went onward. But while some fishes may be degenerate (degraded) amphibians, they have gone on up again in their own way, till no creature is better adapted to its place in Nature than the highest kind of fish.

Muscles.

A few words about how bones are moved, and we are through this tedious talk.

The muscles are the great movers. In the low creatures they form all the body—even in those which can move readily, as the worms. But speed and great strength usually mean a skeleton of some sort; and in the backboned creatures most muscles are made fast at each end, to bones, or to other muscles which are so fastened.

In the lancelet the muscles are only two great strips, which are attached to each other at the ends. It is readily seen that by shortening one and not the other a wriggling motion is obtained.

In the lamprey-forms, the muscles anchor to the head; and as we come up the scale these muscles split up and send off parts to every bone that needs to be moved, and anchor themselves at nearly every steady place to be found.

Fishes have few cross muscles, however. The old tendency to lie in strips may be easily noticed. Of course, they have special muscles to move the fins, jaws, etc., but the greatest of all are those which move the tail and the entire backbone—the most important muscles in the vertebrates—the same by which man is able to stand erect.

Nerves.

Muscles are caused to move or contract (they never really push) by means of nerves. Just how

this is done we do not know. It is one of those great mysteries of life, at the vestibules of which we bow and take off our hats and sandals in our ignorance and meekness. If the nerves are cut, the muscles are useless.

We have already seen how the great nerves are cared for in the skull and backbone. The lower creatures had no such place for theirs; and some of them have no nerves at all that we can find yet.

The first of the vertebrates did not wear their spinal marrow inside their spines. When they got a good skull, much of their nervous matter went inside of it, bunched itself into a brain, and then that began to direct the rest of the body. Previous to this the fish's brains were just scattered around loose, almost anywhere about the body. This is another thing for which we should thank the fishes. They do not seem to have put so much of their spinal column into their skulls as they might, for the latter is not entirely filled with the brain, but has space to spare, which is occupied by a fatty sort of cushioning. It would seem, therefore, that the fishes may have been even more brainy once than now—that they have gone down hill in this respect also.

The so-called "head-fishes," in losing a part of their tails, lost the rear part of their nervous systems or spinal marrow also.

TALK XIX.

How a fish may show its raising, and thus keep a family record, along with that found in the rocks; or vestiges, fossils, and parts peculiar to the young.

As noted, we find little fishes, when very young, having the yolk of the egg attached to the outside of the stomach. (See Fig. 62.) We go further back and find the beginning of the fish to be a mere speck in the white on the outside of this yolk. We see that this yolk, as the young swims about, shows as a vestige (left-over part) of a former condition. We know that the fish in its growth once had no shape except that of the egg.

So likewise we find creatures yet that are single cells, or little balls of living matter. Those of which we spoke, as simply flowing around their food, are really such. The little fishes seem to have begun at the beginning.

Later we find our fish a mere string upon the yolk, with no heart or head or limbs, yet the blood is pulsating in it. It is apparently a mere worm. There are similar worms in Nature; in fact, the lowest fish-form, the lancelet, is just about this sort of a creature.

If we look a little later, our fish may be seen to have peculiarly tufted gills on the outside. These are

yet found in the free young of the lungfishes; and in the grown ones they have been drawn inside and remain yet as mere stubs. But above these are grown-up fishes that never have tufted gills. Behold, a few days later *our* little fish has drawn *its* tufted gills inside, and has put on gills like those of the ordinary fishes. It seems to be tracing here in its egg the various grades of gills found outside.

Again we watch its tail. It is straight at first, as that of the lancelet; turned up later, as that of the low shark-forms; a little less so further on, but still it is long; then finally it is shortened like that of the birds, and is the same as that of all bony fishes, with a peculiar spread-out end for the rays to grow around. Is it not singular that this little tail as it grows should thus mimic all the tails below it?

Let us look at the tail-fin. In the little fish it is a simple fold of skin at first, running all around the tail above and below it and far forward. It is not broken up yet into parts. The lowest fish-forms are that way yet. After a while—even after it swims—this great fold has had rays grown into it, and has divided into the dorsal fin, the ventral fin, and left the tail-fin on a stem, to itself.

The case would be the same if we looked at the air bladder, the mouth under the body, and many other things which we have not even mentioned in this little book.

Now, since we find this youngster telling us so much by its mimicry of the order of things which we can see is the real order of arrangement in Nature

(such as the cell, the worm, the lancelet, the tufted-gill fish, the turned-up tail fish, the far-back mouth fish, and so on), we can trust it a little bit if it hints at some things that we have not yet found, or may never be able to find; for there are many lost links in Nature. We have been doing some of this sort of trusting as we came along, and the author wishes now that you may see the reason for the faith that was in us.

Sometimes creatures have what is called a larval form, just as the caterpillar is a larval form of the moth. More nearly to our case is the tadpole which is a larval form of the frog. All these larval forms show a state up through which the race quite likely came.

Some of our eels have a larval form. It sometimes happens in other creatures that the growth ceases in the larval form, and they remain in this state and lay eggs to rear young. Thus one amphibian may so remain always young in form, at least, and under certain conditions breathe by gills; but under other conditions it may grow on, lose its gills, and breathe by lungs. This shows how much a creature may be shaped by its surroundings.

Some students have never been able to explain many of the peculiarities of the shark-forms; but by supposing that they are such (arrested or stopped) larval forms of what was once a higher fish, their relations to the others seem more natural. There are many hints that point that way.

We have seen that the flatfishes appear as if they once swam up edgewise, because they have bodies

shaped slightly like those of the sunfishes and perches. The young swim so yet, and the progress of the lower eye over the head may be watched, showing that this is a late development for a special use. If we had not seen the young, we could not be so sure of this, for there are no forms now between the flat-fishes and the usual kind, though some of the former are flatter than others. Little sunfishes sometimes lie and swim on their sides.

We have to be careful, however, about believing everything which the growth of young things indicates. Nature hurries many processes very much, and seems to get so anxious about important things—as we noticed in the eyes and the pectoral fins—that her method in one place is not always to be trusted, unless she has hinted strongly at the same thing in another.

We have seen in so many cases where old things have been retained for new uses, or have been changed into new tools!

It may not always follow, therefore, that certain parts found about a little fish belonged once to its forefathers when they were grown. It may be that such as plates, weapons, etc., are necessary to protect the young in their defenseless state, and are lost by the old fishes because they are not needed. Nature can put on certain things at certain needed periods, as we may see, when she gives the deer horns at that time only when he has to fight his rivals, and takes them off quickly later that he may better escape his foes.

We have had much to say of the angler; but this last is about its baby. Here is a picture of it. For a long while naturalists thought the young was another species. You recall that some of this family live in *floating* seaweed, but the parents of this one lie on the bottom. Note the tentacles or strings projecting from this little fellow, which show that now, as a baby, it may hide much in floating seaweed also. Now, if there were no kinsfolk living in this way, we should think this merely a peculiar protection to the young; but since we find one of this group sewing a nest to the side of seaweed, another with a fin converted into a mouselike foot for crawling through it, we feel, therefore, that seaweed was once the home of the now mud-loving angler. Perhaps he found it better fishing farther down, and lost his lower streamers because he did not need them there.

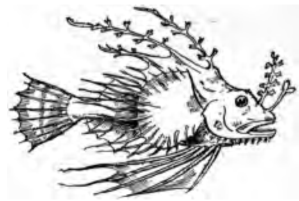

FIG. 69.—Young of goosefish or angler.

In like manner the embryos of the rays show that they once had the forms of sharks, before they took to lying flat. Many even more striking examples might be cited. Nature makes everything as comfortable as she can in its chosen place; but she keeps books, and is apt to write the history of a creature's changes in a record of scars and worn-out tatters which show somewhere in life a reminder of better or baser conditions in the past.

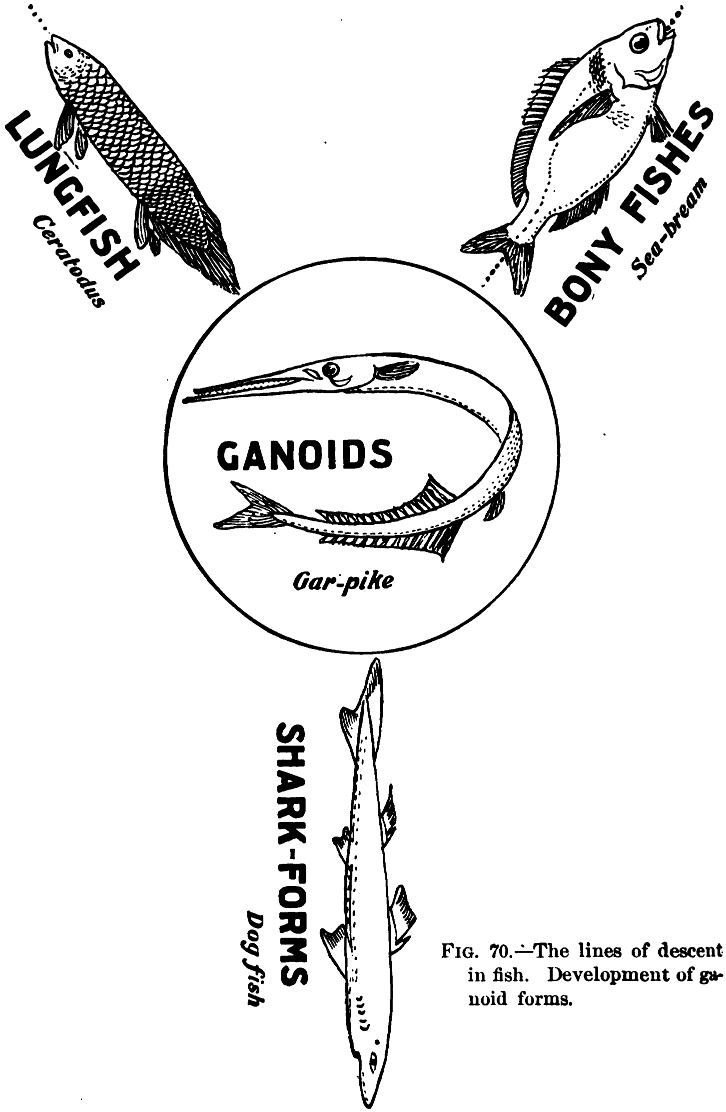

FIG. 70.—The lines of descent in fish. Development of ganoid forms.

The Record in the Rocks.

Of the fishes, rather more freely than of any other vertebrates, Nature has kept a record in the rocks. Especially of the bony fishes is this an easy matter, since their forms flatten out so easily, and become pictures of their skeletons in stone.

Fishes were always found in the water, and hence were likely to be caught in the mud and formed into the rocks, when the earth itself was in the gristly state of soft clay, before it was hardened into the bones of rock.

By no means all fishes, however, as we have seen, had bones to become petrified (converted into stone), but their scales, teeth, and even the sharp toothlike points on the skin, the contents of their digestive tracts, and other little things, often tell what sort of creatures died here. Sometimes the odor of the oil left can be yet recognized. Think of a fossil odor millions of years old coming from a fossil grease spot!

While it can not yet be definitely shown just what was the earliest form of fish which is found in the rocks, it is certain that fishes near-akin to the sharks, sturgeons, and lungfishes were among the earliest, for they are all found away down low.

By permission there are presented here pictures (from Le Conte's Geology) of some very low kinds, which show that fishes were varying very rapidly in those old times, as if Nature were searching for the form that should suit each little niche of the world best.

Now look at that of Fig. 71. It is one of the sturgeon-forms (called Ganoids). It shows evidence of being degraded to a bottom-haunter purely; for its eyes are close together on top of the head,

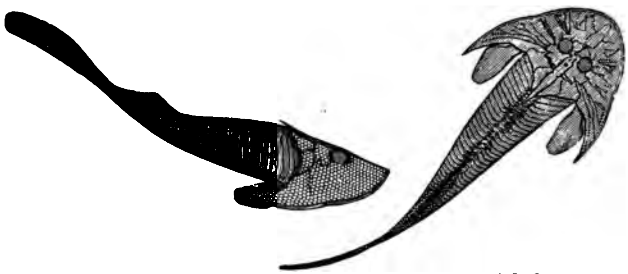

FIG. 71.—Ganoids (*Cephalaspis Lyelli*). (After Nicholson.)

and it is armored with a great bony mantle which has wings that run out and protect the pectoral fins. It appears as if it were on runners and might have pushed itself along the bottom with its tail elevated above. The ventral fins are gone. It was a little fish, and may have had these barbed head-plates to prevent its being easily swallowed tail first. The

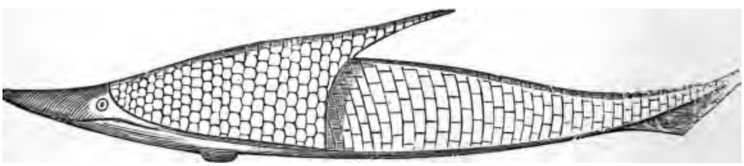

FIG. 72.—Pteraspis restored by Powrie and Lankaster. (After Dawson.)

fish at Fig. 72 seems similarly formed, but appears as if it were shaped to stir up the mud at the bottom.

It was very fashionable in those days among fishes to wear great plates for protection. These sturgeon-forms that were so dressed are called *Placo-ganoids* (plated Ganoids). Note them at Figs. 73 and 74.

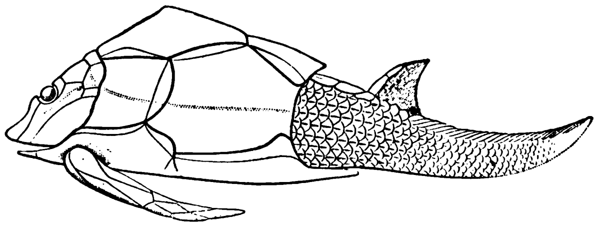

FIG. 73.—Pterychthys restored. (After Traquair.)

This form of fish did not seem to be best fitted to last—perhaps because these plates became too stiff and heavy for good action. They soon gave way to other fishes with smaller plates; and, as we have seen, these plates finally give place to scales. In Fig. 73 there is a sort of half-and-half condition indicated. Note the early flipperlike form of the pectoral

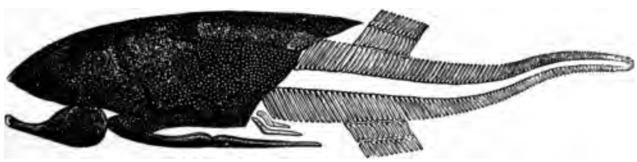

FIG. 74.—Coccosteus decipiens. (After Owen.)

fins here, resembling much those of some turtles. It seems not unlikely that from these fishes the reptiles (turtles, lizards, etc.) got their start. Professor Gill states that the *Placo-ganoids* were the first, and the

lungfishes were the next; so that the amphibians began along here also somewhere. Here is a very early hint of a sort of bottom-crawling limb. Possibly the lungfishes tended thus strongly to become

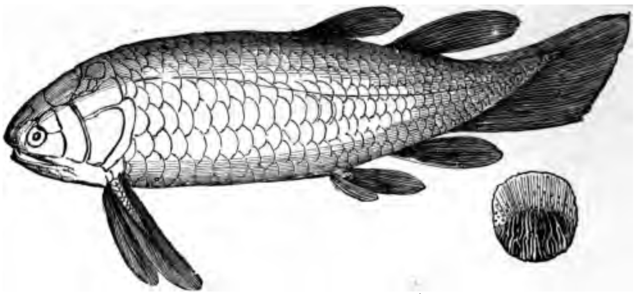

FIG. 75.—Ganoid (*Holoptychius nobilissimus*). (After Nicholson.)

four-legged by *crawling* on all fours on the bottom before their offspring, the amphibians, walked ashore; so also paddle-fins may have had their start. In the next three figures (75, 76, and 77) these paddle-fins

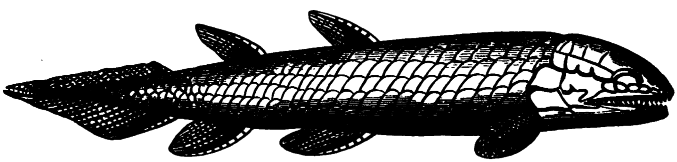

FIG. 76.—Ganoid (*Osteolepis*). (After Nicholson.)

are still found, though these fish are quite modern in appearance—having all the usual fins, and having tails that are not turned up at the end. These were doubtless akin to the lungfishes. Fig. 78, while yet showing a sturgeon-form, hints much of higher fishes, and has ordinary fins.

Here also Professor Le Conte has pictured the nearest living kinsfolk of these old-time fishes. Fig.

FIG. 77.—Ganoid (*Glyptolemus Kinairdii*). (After Nicholson.)

79 is the *bichir*, already noted as a fish (not a lung-fish) which has paddle-fins (sometimes called fringe-

FIG. 78.—Ganoid (*Diplacanthus gracilis*). (After Nicholson.)

fins); Fig. 80 is the bony garfish (a sturgeon-form), and Fig. 81 is the mudfish or bowfin, already alluded

FIG. 79.—Bichir (*Polypterus*).

to as being on the line between sturgeon-forms and bony fishes. The gar and the bowfin also have quite

lunglike air-bladders, you remember, and do actually breathe by them. They live now.

There are yet living some shark-forms that are much like those of old. All these just described

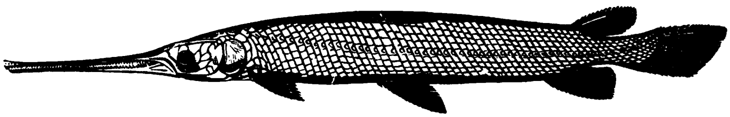

FIG. 80.—Garfish (*Lepidosteus*).

fossils are called Devonian fishes. The lowest sharks had teeth adapted merely for crushing, the next had

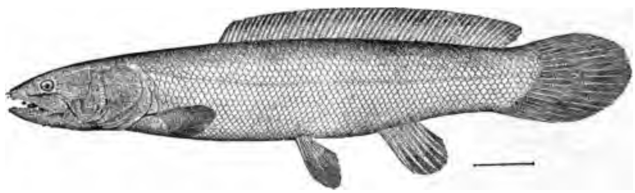

FIG. 81.—American bowfin or mudfish (*Amia*).

teeth which were round and sharp, for piercing or holding, and later, like many alive now, there were

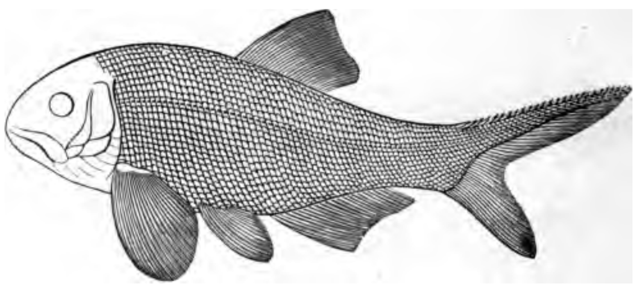

FIG. 82.—Ganoid (*Amblypterus macropterus*).

those which had teeth that were flat, and shaped at the point like a surgeon's lance, especially adapted for

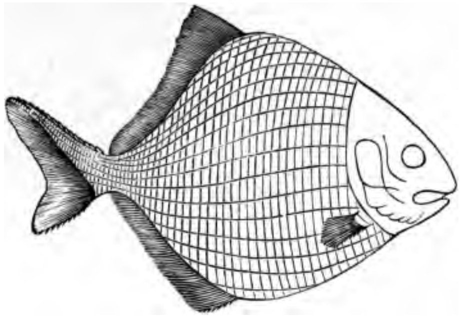

FIG. 83.—Platysomus gibbosus, Permian of Europe.

cutting. Thus in their teeth we may read the progress of the sharks away from the bottom of the sea.

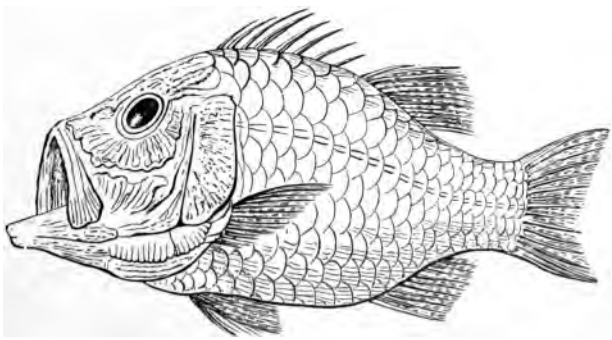

FIG. 84. -Teleost (*Beryx Lewesiensis*).

There were yet in this and the next two geological periods no bony fishes. Farther upward the tails of the sturgeon-forms begin to straighten a little

and to run not quite so far into the tail-fin. The lobes of the tail-fin also began to be more nearly equal, and some sharks (Fig. 82) and some sturgeons

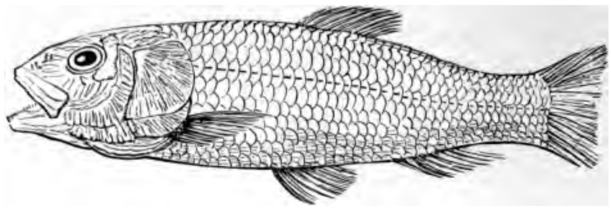

FIG. 85.—Teleost (*Osmeroides Mantelli*).

(Ganoids, Fig. 83) began to show shapes that fit them for muddy-water swimming. Not, however, till we get up to the so-called cretaceous (chalky) period, where lime and bone making matter seemed so abun-

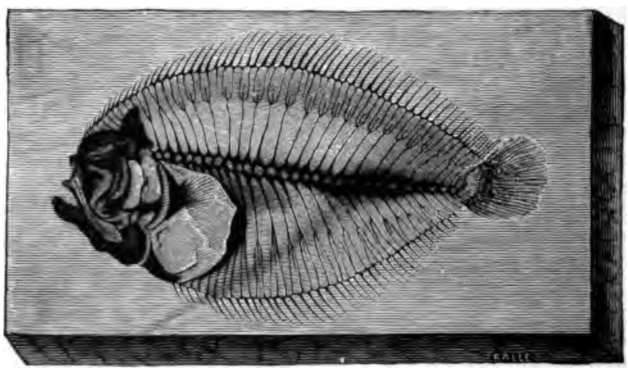

FIG. 86.—Teleost (*Rhombus minimus*), a flatfish of the Lower Eocene.

dant, do we find the bony fishes. We evidently have not yet found the earliest of them, for the lower forms and higher forms appear much at the same

time closely associated. Thus the soft-rayed herrings, salmons, and pikes, and the higher spiny-rayed perch-forms (Figs. 84 and 85), some of which live yet today, are found in the same rocks.

From this on, the bony fishes are more abundant, and in the next age they have assumed all the shapes known to us now. Even distinct genera (divisions) of the flatfishes (Fig. 86) can be recognized.

Disease and Enemies, etc.

When we note how many different kinds of creatures have been exterminated in the past, we wonder what may have been the cause. In a few cases, perhaps, great and sudden changes in the surface of the earth may have deprived fishes of water, or cracks in the bottom of the sea may have let up poisonous gases; but it is more probable that many creatures grew so much in certain directions that they could not change with the *gradual* changes of the things around them.

Thus those great *Placo-ganoids* may have kept on getting heavier or stiffer armor, till they became too awkward to catch active prey.

Again, new enemies may have arisen which began to prey upon them, or some disease may have set in. Nature holds her balance as much by death as by birth. In this cut of a rock (Fig. 87) you may see that death came long ago to quite a bunch of fishes —perhaps from the drying up of a pool.

Our modern fishes die of diseases, though they are usually quite healthy creatures. The carp is

known to live two hundred years, and it has been asserted that there are some in Europe that are even six hundred years old. We can not enter upon the subject of the diseases of fishes, unless it be to add that a sort of mildew or fungus sometimes attacks them, and, while yet alive, they decay away in spots—much as a potato may rot.

Fishes have also many internal parasites, even in the tissues, which may or may not impair their health.

FIG. 87.—Teleosts (*Lebias cephalotes*), Miocene.

It is stated that there is not a fish known which may not have parasites in the digestive tract, and that on the French coast they all may have them in their blood. It is a subject not very agreeable to think of, and is mentioned only by the author, that his readers may order their smelts, properly dressed, unless they prefer to get more than they call for. The blood parasites are not very formidable.

Fishes endure wounds which would tend to be more fatal to higher animals; and there is much that seems to mean that they do not suffer from them so keenly as we might.

Below the fishes, many creatures replace lost parts readily; and above them the salamanders will grow a new tail, or leg even, if it be lost; but in the lungfishes only among fishes can the tail (and not the legs) be regrown if lost. The higher fishes—as well as the other higher animals—have developed so, that only the tips of the rays and the films between them can be regrown, just as we repair the wear or loss of our nails. This is another hint at the low origin of the lungfishes and the amphibians.

While man by continuous fishing has almost exterminated some fishes, especially in certain streams and coasts, yet he is by no means their worst enemy. Many birds live solely on fishes.

We have noticed how they feed upon each other. Their greatest enemies in Nature are their larger associates.

Water snakes catch fishes. Some sea snakes have a poison, which at once relaxes the spines, so that they lie down, thus enabling the fish to be more easily swallowed. Whales, dolphins, and turtles are fish foes. The whale may dash into schools and swallow hundreds at a gulp. Flying fish often arise at the approach of a vessel which, it is supposed, they mistake for a whale.

Among the mammals (besides man) the fish-foes are the seal tribe, the otters, the minks, martens,

and even the bears, cats, and at times foxes, as we have seen, and the bear's little cousin, the coon. But these last are not expert fishers.

Among the birds, fishes find many foes. Nearly all the water-birds are peculiarly fitted in bill, legs, and toes for pursuing or capturing fishes. Loons, cormorants, some ducks, etc., swim after them under water, using their wings as fins; herons, cranes, etc., stand in watch, and grasp or spear them as they pass; gannets, gulls, petrels, and many others, as the kingfisher, throw themselves beak foremost on to them, when near the surface, while the flat-billed ducks, the sandpipers, etc., feed upon the eggs on the bottom and around the edges of streams. The osprey, among the birds of prey, it is well known, seizes the fish with its claws. Even away up on the edge of the highest birds, the water ousels walk on the bottom, eating eggs and seizing the young occasionally. Man's methods of taking fish will form a talk by itself.

It has been stated that certain lampreys have been seen clinging to shad and sucking their eggs directly away from them as they swim.

TALK XX.

How a fish is brought up by hand and helps to feed the nations; or fish-culture and fisheries.

FROM the earliest times of which we know anything some interest has been taken in raising fishes in a sort of domestic manner, as we raise hogs or hens.

There were fish-ponds among the most ancient Egyptians; and the Romans developed this industry very largely. They had great vats at their homes, besides large pools at other places. They put up eels to fatten them as we put up pigs, and it is said that occasionally a disobedient or disliked slave was thrown to them, to be suddenly nipped to death by the greedy creatures.

But this was not fish-culture as we understand and practice it now. It was rather fish-taming. It is said, however, that the Chinese practiced for ages a sort of fish-rearing that was beyond this; for they searched for eggs in order to put them in other waters or streams, that the quantity of food might be nearer and more plentiful. To make this easier, they placed rude frames in the water, upon which the fishes might lay their eggs. They thus built a sort of nest for the fish, as we build one for the hens.

By this means the eggs were more certainly obtained and more easily carried. Besides this, they had many other rude implements.

The change of spawn from one stream to another was thus kept up in various countries, in a small way, till rather modern times; but, as a rule, when a pond or stream needed "stocking," they caught the fishes themselves and put them in it, as the old Romans used to do.

Either of these methods was tedious on a large scale. It was not until away down in the middle of the eighteenth century that the Germans and the French—both about the same time—learned how to take the eggs directly from the fish in the great quantities in which they are found. They hatched out these, and allowed the parents to go free to lay more eggs for another season.

They pressed the eggs out by the hand at the time when they were ready to issue. In one case this method was first suggested, it is said, by seeing a salmon rub her under side against the heap of stones (usually styled nests) and thus press the eggs out.

We have seen that what more largely keeps fishes from being abundant is the loss of the eggs, by their being eaten, being unfertilized, and not being properly situated for hatching.

In artificial hatching all the eggs are secured and kept safe, nearly all are hatched, and the young are kept secure from enemies till they are fairly large.

There is one enemy of small fishes that has not been mentioned. It has at times greatly annoyed the

fish-culturist. It is that giant water-bug which we so often see dead or stupid under the arc electric lights in our streets. It seizes little fishes, pierces them with its long beak, and sucks the fluids out of them. Doubtless it is rather a good thing for the fishes that man has made himself a better light.

Sometimes the eggs may be sent a long way and put directly into the streams, but it is better to have them hatched first. Recently, small fishes are shipped wherever they are needed.

Fishes' eggs may be either a long time or a short time in hatching, according to the temperature of the water. They may be started in warmish water and then put into cool water, and the hatching is delayed for some time just at that stage, without destroying the life. In this respect fish eggs differ largely from bird eggs.

This peculiarity enables them to be canned, packed in a cool place, and shipped from our Atlantic coast to the Pacific, and the reverse. In this way the shad has been carried out West and dropped into the head waters of the streams. Thence they begin to go downward to the ocean (tail foremost in swift places), and the next and following seasons they come back for spawning; and they thus become fixed residents.

There are, however, different temperatures of water which best suit the hatching of different eggs. We shall not go into that, except to call attention again to the fact that the eggs of salmon families and some others require the water to be not only very

cool, but it must be constantly in motion and have a great deal of air in it. This accounts for that instinct (which is here perhaps an inherited memory) that drives the salmon far up the elevated streams in which they find such water. It tells us again that their forefathers were rather northern fresh-water fishes, as their cousins, the trouts, are yet.

We spoke of the little fish going down stream tail first as it leaves its nursery. This position is necessary in rapids, in order that the tail may be ready to leap, dodge, guide, etc. Besides, as we saw, swift water running the wrong way will drown a fish. In this case, however, the traveling is done by floating in the current, the tail merely steering. It could not steer much if it pointed up stream. The tail in this position could certainly help the fish along, however, if it chose to go by it. It has been asserted by a very high authority (Günther) that a fish can move backward by the use of its pectoral fins only—not by its tail. It *may* be that this is true if the fish is free; but every angler knows how a hooked fish can pull by flipping its tail when it has its head anchored by a hook and line.

It must be admitted, however, that the whole swimming system is *much* more effective in going forward. The author once hooked a ten-*inch* trout in the dorsal fin, and as it pulled away with its head down it felt as if it were a "ten-*pounder*."

Very fortunately, the fishes more easily raised by hand are those which are good for food, and best suited to our inland streams. Such are the salmons,

trouts, pikes, shads, carps, basses, breams, and others known as game fishes. The carp is easily reared anywhere, and fattens as a hog. The little goldfishes are carps, originally from China.

Of course, where the young are born already hatched it is impossible to increase them by artificial means; nor is it desirable, since, as a rule, with exceptions, such are not especially good for food.

It is impossible here to go into the description of the various kinds of boxes, troughs, cages, ponds, and other things that are used in fish-culture. They are different for different fishes, and are being improved yearly. Fish-culture has grown rapidly since it began and is making great strides yet.

Perhaps no country is ahead of our own in this. Not only is the General Government constantly experimenting for the free use of the people, but now nearly every State has its own hatcheries, as these places are called, and there is a special fish commissioner, whose business it is to send out little fishes, so long as the supply lasts, to all who ask for them.

Unless you live in some fishing town upon the coast or near some large inland canning factory, you are not apt to have an idea or estimate of the great value of fishes as a food and a livelihood. Even many persons dwelling near our rivers make their living catching fish for market. Fishes form a much larger part of the diet of many folk than inland persons are apt to think. A walk through the fish markets of a large city—a walk always worth taking—will show us much. In many places fishes are decidedly the

cheapest meat which can be purchased. In no other way can we so well make the waste of waters help to feed the millions of people crowded upon the points of dry land which stick up here and there, as by learning how to get from it fish and similar things for our tables. Some thinking persons fear that the soil will not be able to feed all the people after a while, and one of our hopes lies in getting more from the sea.

Fisheries.

This brings us to talk a little of those regions where fishes are found at certain seasons in great abundance—called fisheries. We have been compelled to refer to them as we came along.

Such places have been known in the Old World for ages, and large catches were made by the ancients. The eel-forms, of which the Romans were so fond, were caught in the seas around Sicily and brought to Rome by shiploads. Other kinds of fishes, especially cods and herrings, became the source of great wealth to the various nations.

Along the coasts of Scotland, Ireland, England, and France also there are certain great fishing places. The Mediterranean Sea was famous very early, as well as many inland rivers and lakes—notably the Sea of Galilee.

But we have not space to attempt to outline all the great fisheries of the world, or to give any figures representing their yearly value or the amount of money put in ships and machinery for working them.

Nowhere are there found such large fisheries as

those along the northern Atlantic coasts of our own continent, extending from Massachusetts to Labrador. Especially on the banks of Newfoundland are codfishes, herrings, and mackerels caught.

Nations have gone to war over fisheries, for they have been greedy about them. In less than seven years after Cabot discovered the North Atlantic coast and reported its fisheries, the French were sending fishing fleets to it, and the other nations soon followed. By the time at which the French and Indian war began there were as many as one hundred and fifty vessels coming here yearly. France paid bounties to encourage the industry. Now those going there are numbered by many thousands, and the money invested is counted by many, many millions.

Besides the cods, herrings, and mackerels caught for food, many other kinds of fishes are sought for other purposes. Thus the Chinese catch sharks for their oil and their skins. The French have their sardine fisheries; hake and ling are caught on the shores of Scotland, while sprat and herring are taken elsewhere around the British Isles.

Some fishes are caught purely for bait to lure other fishes, being put upon hooks or cut up into bits and spread upon the water, so that the nets may better get at the feeders. Others, as menhaden, are caught for fertilizers of old worn-out soils. Their dried bodies are ground up fine and sown over the fields. This is another method by which the ocean is made to help the land support the people.

Among our fresh-water fisheries the salmon fisheries of Maine and those of the great Columbia River of the West are among the best known.

In the West, especially, great quantities of salmon are canned yearly and shipped all over the world.

In every nation wise laws are enforced to prevent the entire destruction of the fishes. They allow only certain seasons in which to fish, and only certain sizes of fish to be taken.

TALK XXI.

How a fish is headed off at times and may be taken by hook and by crook at others; or a few fishing methods.

Our interviews are drawing to a close now. Let us talk this half-hour about the methods employed to capture fishes. We have already spoken of boats being used to go to the fishing grounds, or waters rather, and of course to bring the fish home in. In order to learn much about the management of these boats, this writer advises all his readers to study Mr. Kipling's Captains Courageous, which seems to have been written almost as a text-book upon fishing tactics on Newfoundland Banks. The author had evidently made a study of our American fishing fleets and their methods.

Fishes are taken either in nets or upon hooks, even in the ocean. But the scheme is much larger than we inland folk ever see it practiced at home.

In England they call a *trawl* a great purse-shaped bag made of strong netting. Perhaps the word stocking-shaped would be better, for with us the old-fashioned purse has disappeared. This net, however, is larger at the mouth than it is farther back. It is supported and kept open by means of a great beam projecting from the ship. The under

edge or lower lip of the mouth—often from forty to eighty feet wide—drags on the bottom as the ship sails or steams along. This scoops up the fish that are within its reach; they rush back into the bag,

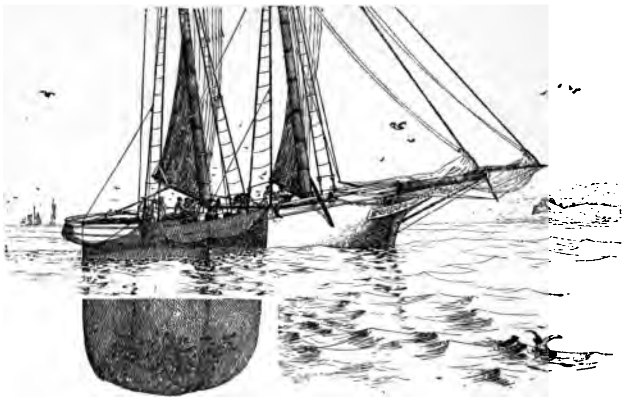

FIG. 88.—Trawl or bag-net.

where there are great side pouches into which they go, in trying to get out. Over the mouths of these pouches are valves or flappers which prevent any return of the captured fish toward the front of the net. The flappers easily rise up as the fishes go in, but lie flat as they attempt to come out. The principle is the same as that used in many rat-traps.

When the tide is running out, and the fish are going with it, these trawl-nets are frequently fastened to the bottom of the ships, instead of to a beam, and are drawn against the course taken by the fish, by which means they are caught and secured as before. When fishes are thus going out with the tide

a seine is also used; but we speak of that form of net later.

Perhaps the most effective method of taking many fishes which are running past in shoals or streams is for the fishermen to get ahead of them, if possible, and drop, in the line of their travel, long deep *walls* of netting, known as drift-nets. These are buoyed at the surface and have their meshes (spaces between the strings) of that size which suits the kind of fish passing; for this net takes and holds its captives by allowing them to thrust their heads, and perhaps a little bit of the body only, through the meshes. The gills or front fins then prevent the fish from backing out, and when the net is drawn up the mackerel, her-

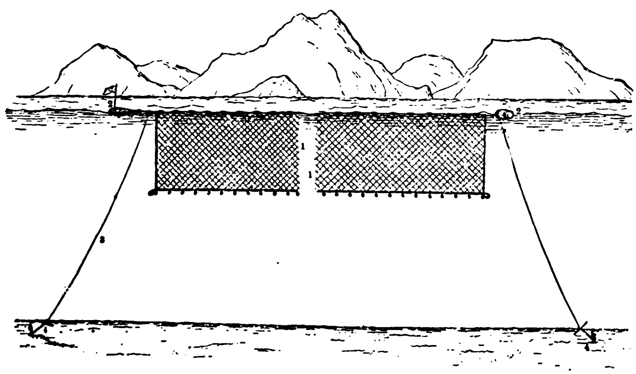

FIG. 89.—Drift- or gill-net at surface.

ring, or whatever kind of fish it may be, is sticking in the nets—often in great numbers. These are frequently called gill-nets, because the fish usually hangs itself by the gills.

A fish may get terribly tangled in a string. The author had an experience once which sounds so fictitious and fishy as to be out of place—at least out of the range of belief—anywhere else except in this connection in a fish-book. Wishing a specimen of the commom "mud-cat" he set a single hook in a little shallow mud-bottom pond, where he knew a school of these fishes lived. Then he went away for a few hours, and on his return homeward drew up his line. What his surprise was you can imagine when there came out with it *three* fishes and the limb of a tree. One fish was hooked as a decent fish should be, a larger one just above it had the line wrapped twice around its neck and drawn tight into the gills, while above this still a larger one yet had the line three or four times around its body on each side of the pectoral spines, with a turn or two taken around one of the spines itself. The lower fish was dead and had the entire contents of the body cavity eaten out—perhaps by a turtle!—the other two were alive but very stupid. It is probable that these fishes approached the bait in a bunch; that one became hooked, and in its attempt to escape it wrapped the line around its fellows and the bit of brush that lay near.

It is the fishes with sharply shaped heads that are apt to be caught in gill-nets. Such fishes swim with greater power and swiftness than others, and drive themselves more strongly against the meshes through which their pointed heads easily make their way. Those usually taken in this way are mackerels, her-

FIG. 90.—European bream (upper figure). Pilchard (lower figure).

rings, and pilchards. These latter are very common on the coasts of England (see Fig. 90). It is stated that by means of drift-nets "ten thousand hogsheads, containing twenty-five millions of pilchards, have been landed at one port in a single day."

In cod-fishing, the gill-net is used on the bottom as well as on the surface. You recall that the little barbel on the cod's lower jaw tells that it is a bottom feeder, and the flatfishes themselves were quite likely

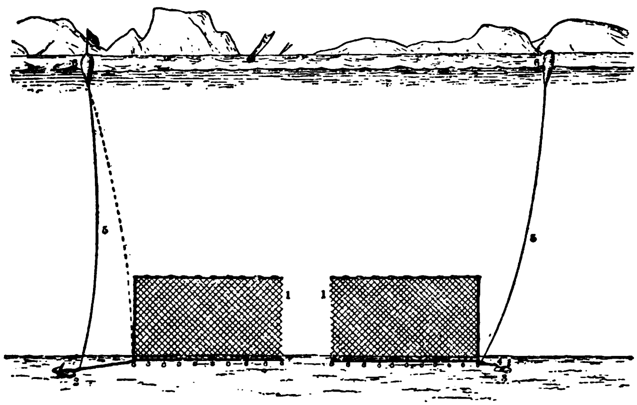

FIG. 91.—Drift- or gill-net at sea bottom.

made out of cod-forms, since their kinship now is so close to them.

As hinted, marine fishes are caught with seines also. These are somewhat like drift-nets or great curtains of twine netting. They are of various depths, according to the water, and of lengths that suit the size of the inlet or landing place where they are used. Some are two hundred feet deep and more

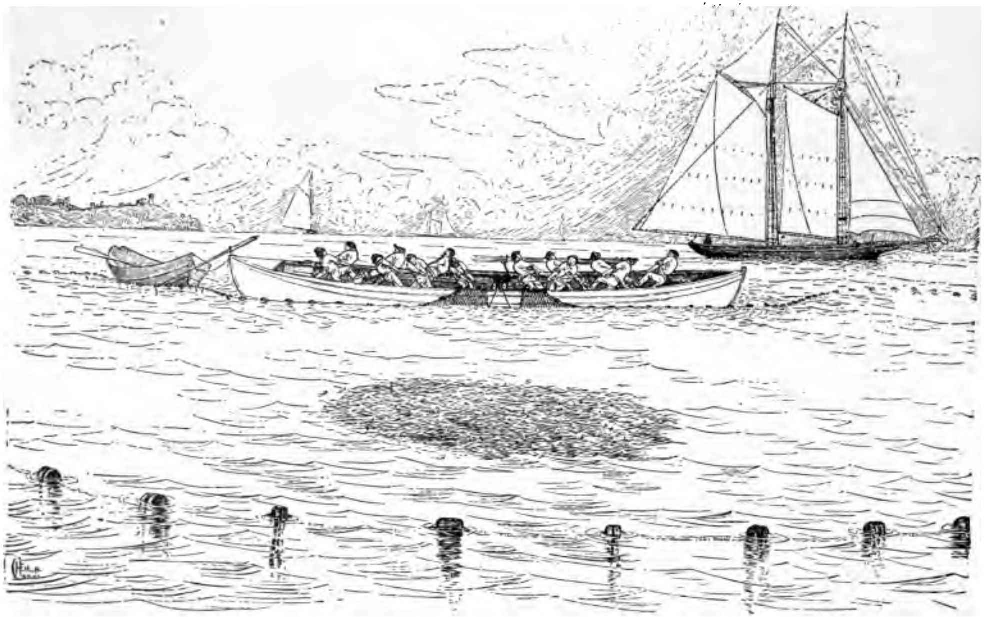

FIG. 92.—Pulling in large seine.

than two miles long. They often have floats made of glass bulbs. They are very expensive when so large. They are set and handled by means of boats, and sometimes special machinery is set on shore to pull them in. They require very favorable shores to make them of special use.

There are also some so-called pursed seines, in which the fishes are secured in pockets that lie behind the wall of netting. These do not require such great care in landing, but may not, in other respects be as effective as the plain seine.

Drag-nets are great bags which are drawn between two boats, usually in shallow water. Some seines are

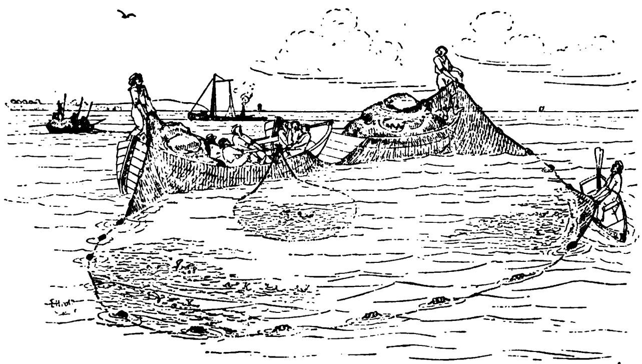

FIG. 93.—Pulling in pursed seine, one end of which is fastened to rock.

made fast to the shore at one end, while the other is swung around out into the water, and then drawn in, often by horse or steam power.

There is another style of fishing in which the net-

ting is not moved but set. It is usually called *trapping*.

Pound-nets consist of a single wing or curtain of netting of the same depth as the water, set on the

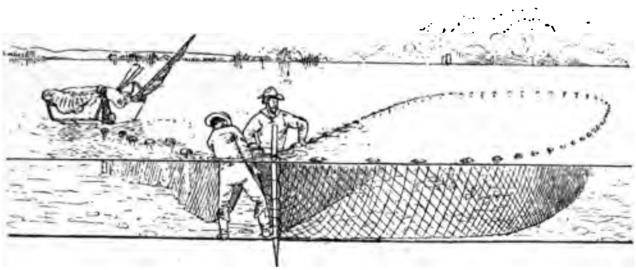

FIG. 94.—Pulling in gill-net that is fast at one end.

bottom with one end at the shore and the other extending, at an angle with the bank, far out into the water. At this farther end is such a pocket as has been already described.

As the fishes swim along near shore they are led off around the wing till they come to the pocket, which they enter, hoping that they have at last got around the obstruction.

Sometimes these obstructing wings are made permanent by being built of stakes, planks, or brush. In this case the wing is called a weir. Weirs are made usually where there is much difference in the level of the water at high and low tide, because when the tide is out they can be easily built.

The fyke-net consists of a great funnel-shaped tube or tapering sack, kept open by means of hoops. It also has pockets at the rear end. From it on each

FIG. 95.—Tide-water weir.

side extend great wings of netting, very much as in a quail net. These wings lead such fishes as happen to swim in between them into the pocket. The pound-net is set on the bottom. Besides being used on the coasts, it is, in our inland lakes and rivers, largely the means of supplying the market with fish.

In taking the traveling fishes as they run up and down the streams at the spawning season, nothing is more effective than the fishing wheel. It is a large wide wheel, sunk a little way into the water at certain narrow places. It has paddles on it, which cause it to turn slowly with the current. On its rim there are set dip-mouthed baskets made of strong wire netting, which meet the fish as it swims up stream, lift it up, and dump it, on the other side, into a chute which leads to the shore.

Of course, if this be set at a point where all the fishes pass, as they may be made to do by weirs, it will catch them all. It is so deadly that certain limits to its use have been set by law.

We shall now glance at the methods of catching fish with hooks, as it is practiced on a large scale by those who fish to live.

In America when we say trawls (or trolls) we mean trawl lines and not trawl nets. These lines are set in the ocean, at a length often of three or four thousand feet, and they carry hundreds of other very short lines, upon the end of each of which there is a baited hook. Trawls may be thrown out either from shore or ship.

Sometimes they have buoys at certain points and weights at others—first one and then the other at

regular intervals. When cast out, the weights sink, the buoys float, and the line takes a zigzag shape, like this, having the hooks thus set at various depths.

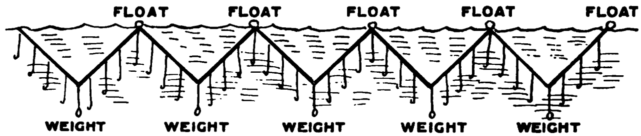

FIG. 96.—Trawl.

Much fishing with hooks is done over the side of small craft with lines handled directly by the men in the boats.

It is said that the Chinese set barbless, unbaited hooks in the runways of the sturgeon, and that many of the fish catch themselves on these in passing.

It would be interesting to follow the development of the fishhook, from a piece of stone tied at the middle to the piece of curved shell, and on to the terrible barb of steel which we know so well now. But we shall simply ask the artist to draw for us here a series of these crude forms (see next page).

Fishes are often speared as they pass the shallow places in their "runs." A special implement having three sharp barbed prongs is used. It is called a gig. It is a very old means of getting a fish. The ancients represented Neptune—their god of the sea—as always bearing about one of these three-tined spears with him as a sign of his power over all the swimming things. It is in this connection called a "trident," which means a thing having three teeth.

One learns to throw these gigs with great accu-

racy. Occasionally they may be shot from a gun, but the charge of powder should be very small, not more than one fourth the usual load. Herrings, shads, buffaloes, suckers, salmons, and pickerels are the more

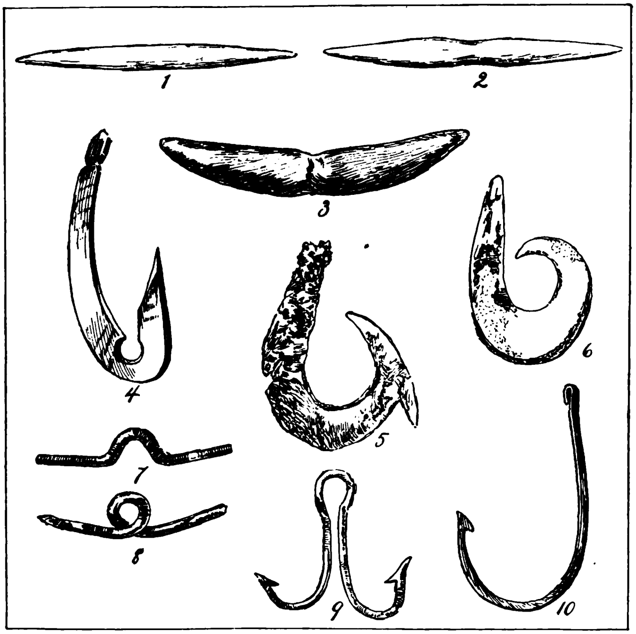

FIG. 97.—*1, 2*, bone gorges from Swiss lakes (lacustrine); *3*, stone gorge from valley of the Somme; *4*, fishhook of boar's tusk from Swiss lakes; *5, 6*, shell hooks from Santa Barbara, Cal.; *7, 8*, bronze wire gorges from Swiss lakes; *9*. double barbed bronze hook (lacustrine); *10*, bronze hook.

usual kinds so taken. Occasionally fishes are shot as they float, but this is not a very satisfactory method.

Single spears are used also in taking the bottom fishes, such as flounders, soles, turbots, etc.

Of course, other crude ways suggest themselves, and have been practiced for ages.

The author recalls a pressing invitation from a South Dakota farmer: "Come up in the spring," said he, "and we'll fish for pickerel."

"What sort of tackle shall I bring, Billy?"

"Tackle! Why, I always tackle 'em with a club."

And it was found, indeed, upon further inquiry, that when in the spring the pickerels ran up into the shallow, narrow little streams of the prairies (which are usually dry in summer), one man in high rubber boots waded noisily in the stream above, while the other stood at some narrow, shallow place and clubbed the fleeing fishes as they passed.

A queer kind of fishing is that where one fish is made to catch another. The habit which we have noted as peculiar to the suckfishes or *remoras*—that of fastening themselves on to sharks—is used by West Indians and some Eastern nations to capture the latter fish. A string is fastened to the suckfish, and it is let loose in the water. After a while it sticks to a shark, and both are drawn in.

It is well known that the Chinese especially train cormorants—a diving bird of the pelican group—to pursue fish under water and bring them in when captured. A strap is put around the bird's throat, so that it can not swallow the prey.

Perhaps, after all, nothing excels in queerness the

method of fishing sometimes practiced by the natives of Africa—that of digging for fish in dry land.

You recall our mention of the habits of certain lungfishes—that of burying themselves in a ball of mud, which dries hard around them, forming a case. You will not be surprised, therefore, to learn that at the dry season the people of these regions go over the bottoms of these dry ponds and dig fish as we dig potatoes or clams.

In the same way we might find certain little fishes,

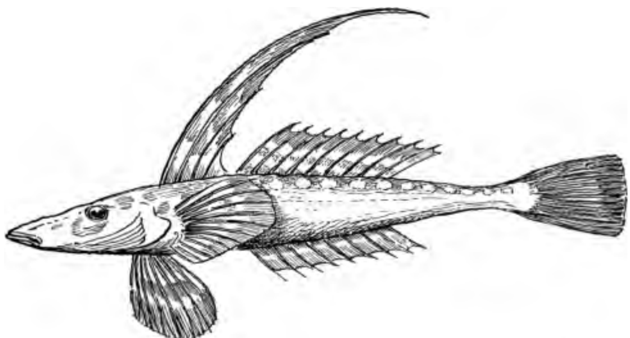

FIG. 98.—Dragonet (*Callyonymus lyra*).

the gobies, under rocks on some parts of our Pacific coast after the tide has gone out. Among the gobies is placed the beautiful dragonet. In other places the mud-skippers may be shot, if we choose, as upland game.

But the method of methods in fishing, when mere food and a living are not concerned, is that with rod and line. While one may fish thus from a small boat, far out in lake, river, or bay, the sport is at its best

only when practiced from the banks of a rather small stream. Here it involves something more than dibbling, where we simply throw in and draw out at random. It means that you should know what sort of fishes are in the stream; what kind of places they lie around in, or where they go specially to feed; what things they generally feed on, and what prey they are after the day upon which you are fishing for them; for a trout leaping at caddis-flies on a certain afternoon is not, on that day, nosing the bottom for "helgramites." It means, therefore, that you should know how deep to sink your line and what bait to use, and even what the color of it should be—or what special color is required for a particular time of day. A fish may leap at a brown fly in the sun and refuse it in the shade, or take a red one at noon and a white one only as the twilight comes on. Lures that are "killing" in one creek, nay, in one pool, may not be noticed in another. With your best knowledge you will often fail. You may try in vain all the lures you know, and yet find a fish hungry and anxiously leaping at the sinker inches above your hook.

Then, the weather: we have seen how fishes are influenced by the changes of it. Just before storms they are active and feeding, for insects are flying low then, and all else is moving, too. It is a good time to go fishing; and one must be a weather prophet, at least enough of one to know when the wind is in the east. There are days when fishes are sullen and simply will not bite, even in biting season. The "times" and seasons are something the angler must learn—

learn to feel in his very bones as the fish feels—and when he feels that the bass are feeding, or the trout rising, then the desire to angle for them becomes a passion whose prompting he can scarcely resist.

He rushes out and has gone back again in spirit to the times when his forefathers wore the plumes of the savage, and with a sinew or a thong of skin tied to a bent bone or a stone crossbar, snatched the scaly giants from their watery homes.

He finds a keen pleasure in matching his human skill against the cunning of the finny tribes, and rejoices in making a slender thread do the work of a cable in tiring out the tyrant of the pools.

TALK XXII.

A glance over the field and a review of the great groups of the fishes, and some of their subdivisions; or families, genera, and species.

WE saw near the first (in Talk III) that fishes are divided into great groups, and we have been compelled to speak of them as so divided; but now we may show that they are further divided and subdivided till we get down to some of those species which we may chance to meet in our daily excursions, either in the field or the markets.

We recall that in speaking of the great groups we found that the dividing line was that one which lay most nearly in the midst of the averages of all the peculiarities of different fishes. Thus the structure of a great many parts had to be considered. We could not well hold fast to any *one* trait as common to all fishes in one group. In our division of the sharks from the higher fishes, for instance, it was stated then that shark-forms had the gill-slits uncovered and that all higher forms had them covered. While this is generally true, there is the spookfish (*Chimæra*), in which the slit is covered by a fold of skin merely, and not by the peculiar bone, which we call the gill-cover.

Likewise the lower jawbone is not hinged as a shark's. But this creature is not a so-called bony fish. It is therefore a connecting link, and the students have felt compelled to put it in a group by itself.

It is true of other fishes that, as a rule, part of their traits point to one class or kinship and the rest point to another. Sometimes these different traits are so nicely balanced, that it is very diffi-

FIG. 99.—The pilot fish (*Naucrates ductor*), upper figure. Spookfish (*Chimæra monstrosa*), lower figure.

cult to assign the fish to its proper place among its kind.

Besides this gill-slit and the jawbone's low style of joint in these spookfishes, they have the peculiar skin, the queer heart, the twisted valves in the lower digestive tract, the teeth, the meeting of the eye-nerves,

the fastening of the gills to the skin, and many other things which seem to point sharkward, but other characters belonging to these fishes are also found among the higher forms only. Scholars differ about which one of these contradicting traits is the most important, and consequently we find many different arrangements or classifications. So great is this intergrading of peculiarities that the sturgeon-forms and the bony fishes are not any longer separated by modern students. Thus the squarish (ganoid) scales will no longer distinguish the former. Some fishes have these and the ordinary kind also. The hardness or softness of the skeleton will not even answer; the garfish is evidently a low sturgeon-form but its skeleton is bony. And so it goes.

Still, these great divisions of shark-forms, sturgeon-forms, lungfishes, and bony fishes take in very definitely all the real fishes, except a few on the ragged edges. Sometimes these latter seem just a little more strongly attached to one group than to the other; and often they appear about to make a group by themselves. It is these things about which the scholars delight to dispute. The author remembers that when a child he wondered why all this could not be settled—not knowing then that any new fact—the finding of a new fish, alive or fossil—may compel a change in classification or leave it a thing to be laughed at. We must not despise the man who pays so much attention to such matters, for we learn of him all we know about classification and structure.

The divisions are matters of human judgment.

Every great naturalist is apt to have a classification of his own. All are liable to err; but even their blunders are helpful. Thus our great naturalist, Agassiz, tried to class all fishes by scales alone. The single feature would not hold, for reasons that we have seen; but he opened the eyes of the thinking world wonderfully, and found a key to the rocks which unlocked a great treasure of knowledge. We have to know something of a fish's history to be sure of its kinship; and without placing it in its proper group, there would be such confusion of unlike forms that we could not even think intelligently about them.

Thus most ganoids (sturgeon-forms) are fossil; only a few genera are living now. They are thought to form the connecting link between all the other true fishes. This relation is shown in the diagram at page 210.

They are thus cousins to them all.

Within these great groups are other smaller groups called *orders*, wherein many having the same forms of internal structure are classed together. This often includes a large number of fishes which differ very much in outside appearance. Under these orders there are certain other smaller groups which are much more alike, and these are known as *families*. Under these still will be found a number of kinds of fishes which have the same rather more outward peculiarities, and these are called *genera;* while, with still more merely outward resemblances, there comes the last grouping—that of a lot of individual or single fishes, all of which are quite alike in every

way except size. These are put into the last division possible, called *species*. We can go no further in dividing, except to say that any one fish is never exactly like any other one. This is the individual; and we know no two individual things in Nature that

FIG. 100.—Lancelet, or Amphioxus (*Branchiostoma*).

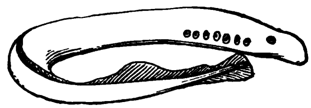

FIG. 101.—Lamprey (*Petromyzon Americanus*). (LeSueur.)

are precisely alike; even the leaves on a tree differ a little from each other.

The lancelet represents all these divisions in itself, there being only the one species.

The lamprey-forms have two orders—the hagfishes, and the lampreys proper. Of this last there are two genera (plural of genus, meaning literally kinds) and several species.

In the shark-forms there are perhaps only the two orders, so frequently mentioned in this book, the sharks proper and the rays. But several families of each may be found even around our North American coasts.

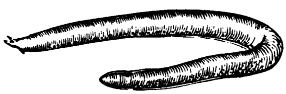

FIG. 102. — Hag, or Myxine (*Myxine limosa*). (Girard.)

The important divisions are represented by the Port Jackson shark, found around Australia, which has crushing teeth only; the great basking sharks, whose teeth are sharp but small; and the terribly

ferocious sharks, the hammer-headed being one of these.

Some of the small sharks, with two dorsal fins, and a spine in each, are called dogfishes. The thresher shark and the porbeagles are other members of this great shark group. Perhaps the most interesting member of this division is the frilled shark, a long, eel-shaped, deep-sea kind, which seems to be widely distributed, and a very old form. While by a scientist it has never been found having a length of more than seven feet, yet sailors have captured so-called sea-serpents which were twenty-five feet long, and which were quite probably this fish. It is doubtless one of the lowest of living true fishes.

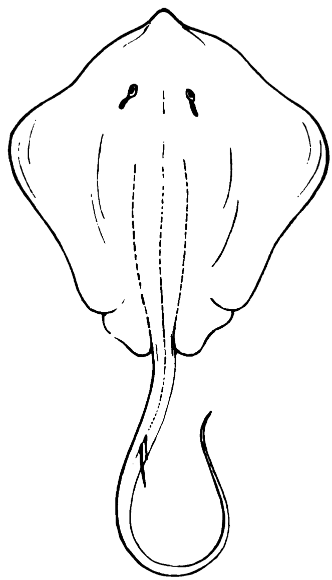

FIG. 103.—Sting-ray (*Trygon hastata*). (Storer.)

Within the shark division (but very like a ray) is the so-called angel-fish, with its pectoral fins, large and winglike. It shows that it lies in between the two orders.

We can not stop upon the different kinds of rays, except to note the sawfishes (see Fig. 44), the sting-

rays (see Fig. 103), the electric rays, the sea-devils, and eagle rays—all forming this group. The skates differ from the rays in having rather a thick tail, two dorsal fins, and the shape squarer.

Skates do not have spines on their tails, and rays do not have two dorsal fins—sometimes none at all.

As noted, the *Chimæræ* or spookfishes form a group to themselves. As you may see by the cut (Fig. 99) they are very peculiar, seeming to lie between the sharks and the lungfishes.

The lungfishes have two orders, as they were originally divided, but since there are known only three species of these fishes now living, we scarcely think of them as forming *orders*.

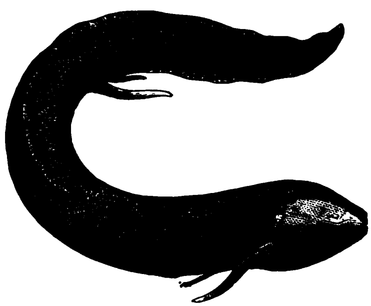

FIG. 104 —Lepidosiren.

The *Lepidosiren* is found in Brazil. Its body is rather eel-like, and its fins are mere fleshy threads. It has evidently been degraded, and has *four* gill-arches. Close akin to it (in the same order) is the *Protopterus* of the Nile region of Africa. Its limbs also are threadlike, and the body is much like an eel's, but it has *six* gill-arches.

The Australian lungfish (*Ceratodus*) has broad, useful fins with scales upon them, and a bone running lengthwise through them. It is the oldest form, and consequently the nearest to the original kind.

In fact, it is a remnant left over from those periods of the long-ago, before our coal was formed in the earth. It more closely resembles the bony fishes than either of the other two which are newer. These last, especially *Lepidosiren*, are very close to the amphibians. By wiggling in the mud, however, they have almost lost their limbs. *Ceratodus* has been placed in a different order from the other two, but there is a tendency now to put all these into one order. All have

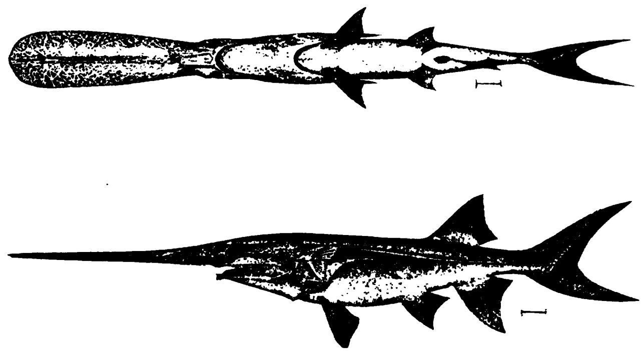

FIG. 105.—The paddlefish (*Scaphirhynchops platyrrhynchus*), under view above.

hearts chambered very much as are those of the salamanders.

Among the sturgeon-forms there are a great many orders, if we should include those found fossil in the rocks.

Of those living now in our waters there are the paddlefish, with its long snout, much like a duck's bill; the garfish or garpike, with its long jaws, so terribly armed with teeth; the bowfins, with their

peculiar degraded gills and lunglike air-bladder; and the sturgeons proper, with their sharp, soft, snoutlike mouths and gristly skeletons. These are our Eastern United States kinds.

Of the bony fishes proper there are now living, the world over, great numbers of orders and families. These are the fishes which we meet and use for food, mostly, and which we pursue for recreation. They are the typical, highest expression of the finny form.

Dr. Jordan, in his manual of the vertebrates—one of the most useful books any Nature-lover can own—notes thirteen orders, seventy-three families, over two hundred genera, and about four hundred and forty species of fishes, which may be found in the waters of our Eastern United States coasts and rivers. Many of these are unimportant, however. There are really only about twenty families which are noted as food and game fishes. A list and description of these can be found in the next talk.

TALK XXIII.

Some finny friends worth knowing and how to know them; or twenty-five families of familiar fishes, and a key.

THIS talk is somewhat in the form of an appendix, and is for reference at any time, even later in life, whenever it may be needed.

Before starting on the descriptions the reader had better review the location, arrangement, and shape of the fins found at pages 29–38, since fishes are distinguished so largely by these. The dorsal and anal, it will be recalled, are often divided. The front part may be all rays, all spines, or part rays and part spines; the spines always before the rays. The rear part may or may not be widely separate from the front part, and it may consist of a few spines and some soft rays, or it may be all spines or all soft rays (rarely). There is usually one spine at least in it, if it is separated from the other part. The anal fin may be similar to the dorsal, but it is not so often referred to.

In describing these, abbreviations are usual, but we shall use figures instead of words, and the letter S. for spines and R. for rays. D. = dorsal; A. = anal; V. = ventral; P. = pectoral. The expressions of the number and arrangement of the fins, spines, rays, etc., is called the "fin-formula."

Our little sunfish is thus described: D. 9 S., 10 R.; A. 3 S., 10 R. This shows that the whole fin has 9 spines and 10 rays, but that they are not separated. If there were separate parts, a long dash is put between, thus 9 S.—10 R., etc. In the codfish, where both fins are divided, the fin formula for D. is: D. 14 R.—21 R.—19 R.; and for anal it is: A. 20 R.—18 R. This shows at a glance the arrangement of the fins, and often distinguishes a fish independent of color or size. Thus we see that cods have the dorsal fin in three parts, the anal in two, and all are soft-rayed—no spines.

The following twenty-five families represent the usual food and game fishes of the Eastern United States, both in the fresh-water streams and lakes and in the waters of our coasts.

If the reader wishes to identify any of the common fishes of the field or market, the whole list of families can be looked over; but a little study of the key at the end will lead directly to the family under which the more important species are distinguished. The numbers in the key refer to the numbers of the families, which follow:

1. The Sturgeon Family (*Accipenseridæ*).—Body long; snout projecting; toothless; four barbels; head with bony plates; tail unevenly lobed; body covered with five rows of shields having ridges on them. Only one, the sturgeon, is really a food fish.

2. The Catfish Family (*Siluridæ*).—Our United States forms have body naked; skin slick and slimy; eyes small; head broad, low, flat; mouth wide; many

FIG. 106.—Sturgeon (*Acipensur sturio*).

barbels; teeth in bands; sharp, strong spines in the dorsal and pectoral fins; eye small and sly-looking. All our kinds have a fat-fin near the tail on top.

Species.

If there are teeth elsewhere than on the jaws, the fish is one of the two great "sea-cats" found on our

FIG. 107.—Catfish (*Silurus glanis*).

coasts. The "topsail," so called, has only two barbels on the chin, while the sea-cat has four.

If there are teeth on the jaws and nowhere else, the fish is one of our "river cats." They are popularly distinguished as "channel cats" and "mud cats." The former has the tail much forked, the latter scarcely or slightly so. The white or silver "channel cat" is good food, and worthy of any angler's steel as a game fish. All are frequently taken at night by setting trot lines across a stream, with a fringe of low-

sunk hooks dangling from them. In the East they are often called pouts, especially one species.

3. SUCKERS, BUFFALOES, ETC. (*Catostomidæ*).—Body scaly, a little high and quite stout at the shoulders; head naked, no barbels; mouth small, sometimes almost round, as if suited for sucking merely; no teeth on jaws; no spines in dorsal; no fat-fins; air-bladder, a long sac, as if tied in one or two places. Lateral line often imperfect or none.

Species.

In the buffalo group and in the "black horse" or Missouri sucker, the scales are large, and the dorsal fin has more than twenty rays. In the fine-scaled suckers there are less than twenty rays. These latter include the common suckers, "stone-toters," the "red-horse," and so-called "mullets." These last two have the air-bladder tied (constricted) twice, while in the sucker it is tied only once.

All are found in our inland creeks and rivers, running up at early spring to spawn. They are often shot as they "float," or speared as they pass the "riffles." They take the hook shyly, and are poor food, except for occasional baking; but they are often avoided on account of the great number of forked bones.

4. MOON-EYES (*Hyodontidæ*).—Body oblong; scales large and silvery; lateral line plain; air-bladder a simple sac, not tied; belly with a sort of keel or sharp ridge; mouth at end of snout, rather cut downward. Rays of tail, about thirty-two; those of dorsal, nine to twelve.

The single species of interest in this family is sometimes called "silver bass," or "toothed herring," but perhaps "moon-eye" is the more common name. It is plentiful in the Great Lakes and the Mississippi Valley. It is of a greenish-yellow color, with silvery sides. Fin-formula: D. 12 R.; A. 28 R.

5. TARPUMS (*Elopidæ*).—Scales immense, brilliant and metallic in the tarpums; smaller in ten-pounder; mouth large, and cleft to or beyond the eye; lower jaw prominent, and having a bony plate beneath it; a fat eyelid; eye large.

Fins of tarpum, D. 12 R.; A. 20 R. Fins of ten-pounder, D. 20 R.; A. 13 R.

These are found around and near our Florida coast, and are much sought after by so-called sportsmen, simply to kill for the mere enjoyment of killing. They are not good for food, but are gamy, active, and difficult to "land" or bring into the boat. The capture of one seems to satisfy wonderfully the destructive instincts of the average angler.

6. HERRINGS, SHADS, ETC. (*Clupeidæ*).—Body slim, beautifully shaped for speed; scaly, with head naked; teeth almost wholly wanting; tail slender and much forked; no lateral line; dorsal fin not larger than the anal. Except in one case the belly is sharp-edged and "saw-toothed."

Species.

There are many species. In the round herring the belly is round and smooth; in the common herring the "saw-teeth" on the belly are faint and there

are some teeth on the front part of the roof of the mouth (D. 18 R.; A. 17 R.).

In the alewife, summer herring, shads, and some others the saw-teeth on the body are strong and there are no teeth on the front of the roof of the mouth. The gizzard-shad has the last ray of the dorsal fin run out into a long thread (D. 12 R.; A. 31 R.). All others except the thread-herring (D. 19 R.; A. 24 R.) have the dorsal ordinary. The shads may be known from the alewife and herrings by having about sixty scales in the lateral line, while the others have about fifty. The former are also deeper-bodied. The menhaden has the anal and dorsal of the same number of rays (19), the dorsal small and far back, and the free edges of the scales are rough and grooved. In the shad the dorsal is nearer to the snout than to the tail. Of course, the gizzard-shad's fowl-like stomach and low mouth easily distinguish it. It is the only herring-form that combines a low mouth, a long filament, and twelve rays in the dorsal.

The herring family is a useful one—at home in the sea, but running up fresh water to spawn. They are at certain times and places excellent food.

7. Salmons, Trouts, etc. (*Salmonidæ*).—Body long, trout-shaped; head pointed; mouth tending to be a little low; barbels none; a fat-fin behind dorsal; dorsal near middle of body; lateral line plain; tail forked; belly round, sometimes flattish in front; vertical fins rather short (Fig. 108).

These are among the gamiest and most toothsome of fishes, giving the angler all the exercise of cun-

ning and skill in hooking and landing them, and rewarding him well for his pains by their excellent flavor and freedom from troublesome bones. They are widely distributed in lakes, rivers, and small streams—largely northern cool-water lovers.

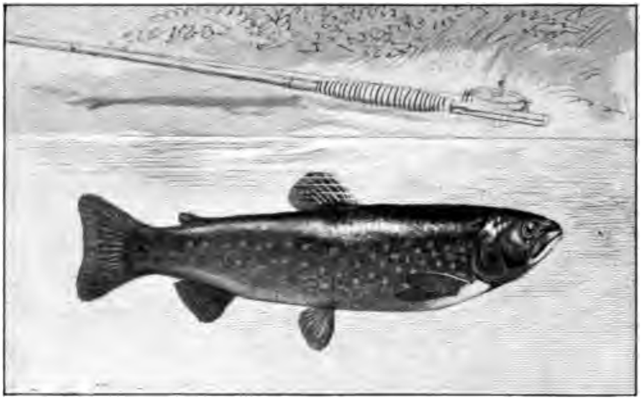

FIG. 108.—Rainbow trout (*Salmo iridens.*)

On Southern coasts many speckled fishes are called trout which do not belong in this family.

Species.

The whitefishes, ciscoes, etc., of the Great Lakes have jaws nearly toothless, and have large scales. Color quite whitish. All others of this group have teeth, and the scales are small or apparently wanting (in some trouts).

The grayling is distinguished by having about twenty rays in the dorsal; all the others have scarcely more than half so many. The ciscoes and lake herring

(so called) may be known from whitefish by having the lower jaw longer than the upper.

The salmons and trouts have teeth on the tongue and not so many as twenty rays in the dorsal. If the front part of the roof of the mouth be flat, the fish is a salmon; if it have a ridge projecting downward, it is a trout. Lake-trout spotted with gray; brook trout spotted with red. These spots are all below lateral line in the true brook trout; in the Rangely Lake forms, the spots extend up above the lateral line.

8. SMELTS (*Argentinidæ*) are usually placed in a family to themselves, but they are really little salmon-forms, with a peculiar saclike stomach, which has the two openings for the entrance and exit of the food almost against each other. No other distinction—except size when grown—can be made.

9. THE PIKES OR PICKERELS (*Esocidæ*).—Body quite long, a little deeper than wide; scales small; lateral line not complete; mouth very large, terribly armed with unequal teeth; the lower jaw noticeably the longer; head scaly on sides, but naked on top; air-bladder present.

Species.

There is only one genus containing five species in America. The pike or great northern pickerel has only half the gill-cover scaly, while the muskellunges have the gill-covers scaleless or naked.

Both are really the sharks of the fresh waters, preying upon any living thing that they can swallow. Like the salmon-forms, they are especially attracted

by a moving object. They are often lured in this way, biting readily at a revolving piece of bright metal, called a "spoon," as it is towed behind a boat. They are abundant in the lakes and streams of the North and Northeast.

10. EELS (*Anguillidæ*).—Body snakelike; vertical fins long, running out upon the tail; scales small or

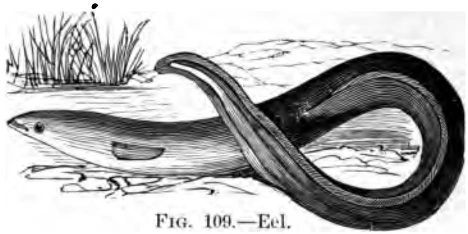

FIG. 109.—Eel.

not apparent; lateral line evident; ventral fins wanting; mouth large and toothed.

Easily recognized; very fat and tender. A prejudice against their form prevents their use as food by many persons, though they are not at all akin to snakes.*

11. MULLETS (*Mugilidæ*).—Body oblong; scales large; mouth small with nearly no teeth; lateral line gone; dorsal in two parts, with four spines in front part; anal fin with two or three spines.

The striped mullet has dark stripes lengthwise; the white mullet is without stripes.

12. MACKERELS, ETC. (*Scombridæ*).—Body long, much higher than broad; head sharp, tapering from

* It seems fairly well established now that the blood of eels injected into the tissues of other animals is as fatally poisonous as snake-venom.

above and below; mouth opening wide, cut far back; gill-slit noticeably large (as is usual in swift fishes); dorsal fin in two parts, with a series of finlets (in all of ours) behind on the tail-stem; finlets behind anal fin also; stem of tail very slim; the fin deeply forked, with lobes very long; colors bluish, steely, splendid; ventral fins nearly as far forward as the pectorals.

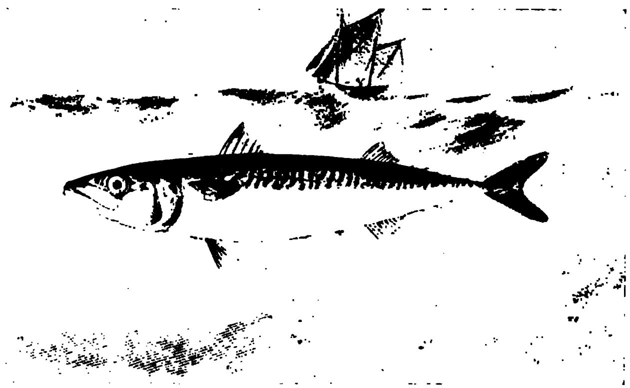

FIG. 110.—Mackerel (*Scomber scombrus*).

Species.

The common mackerel has only five finlets. All our other forms have seven or more. It has also no corselet or collar of scales, like a mantle about the neck, as have all the others. The fins are D. 11 S.—12 R.—5 finlets; anal 12 R.—5 finlets.

The Spanish mackerel is even slimmer, longer, with tail lobes more slender and deeply forked. D. 18 S.—17 R.—9 finlets; A. 2 S.—18 R.—8 finlets.

The kind of bonito found with us is four feet

long. D. 21 S., 1 R.—13 R.—7 finlets; A. 2 S.—13 R.—7 finlets.

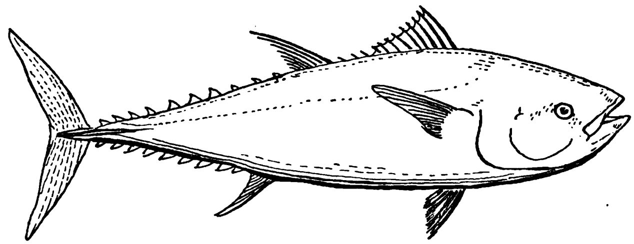

FIG. 111.—Tunny, or horse mackerel (*Orcynus thynnus*).

The tunny is of immense size, often ten feet long, sometimes fifteen. It may be known by its size, but the fins are D. 14 S.—1 S., 12 R.—8 finlets; A. 2 S.—12 R.—8 finlets.

13. POMPANOS (*Carangidæ*).—In this family are some forms sometimes called "mackerels," but they are of smaller account than the true mackerels. The one of curious interest is the pilot-fish (Fig. 99), which is so often associated with the shark and others. It is bluish with six dark distinct vertical bars; no finlets. The scad of our coasts is bluish with ten or twelve dark spots on the side—usually well forward. It has a single finlet above and below, giving it a formula D. 8 S.—1 R.—30 R.—1 finlet; A. 2 S.—24 R.—1 finlet. The "yellow mackerel" is yellow with a black, rough edged spot on the gill-cover, and it has scutes or large scales along the lateral line; no finlets. The pompano of our coasts is bluish *without* having the sides marked with black. Its pectorals are short and not bent or scythe-shaped as are those of the others

noted; anal fin very much like the soft part of the dorsal. Anal has 22 R.; dorsal, 25 R. In the rudder-fish the anal is shorter than the soft dorsal. Anal has 21 R.; dorsal, 38 R. (see Fig. 2, page 5).

The cavalla resembles the pompano, but has pectorals scythe-shaped, and 8 spines in dorsal instead of 6 as in the pompano.

14. Bluefishes (*Pomafomidæ*).—This family has with us the well-known bluefish only. It is bluish with silvery-white under parts; a black spot on the under side of the pectoral fin; spines of the dorsal very weak; the stem of the tail is thicker than that of the mackerels.

15. Sunfishes or Pondfishes (*Centrarchidæ*).—Body quite oblong, much higher than wide, the depth being nearly half the length; body outline curved below and above about alike, as in a pumpkin seed; lateral line present, often much bent upward near the front; scales rather large; mouth at the end of the head, which tapers about the same from above and below; gill-cover ending at rear in a soft membranous point, shaped like a small fingernail or scale (see Fig. 1, page 2).

These are often called perch (or more frequently "pee-yurch" in the Southwest), to which family they are akin, but from which they may easily be distinguished by having always *more* than two spines in the anal fin. Perches have only one or two. Sunfishes are all gamy, active, plucky little fellows, great explorers of unknown waters, always ready to colonize any pond or lake, skipping almost across lots.

Many are small and insignificant, yet always beautiful; but such as the crappies (or bachelors), the so-called breams, the grass-bass, the big-mouthed and little-mouthed basses—usually styled black basses—all of our inland warm streams, furnish some of the best food and most exhilarating angling.

The equal-finned group includes the crappie and the grass- (or calico-) bass. These have a dorsal fin which extends along the body but a little more than the anal. Both are greenish-silvery, with darker green spots or mottlings, varying with the season. The grass-bass has the back of its neck not humped or swelled. Fins, D. 7 S., 15 R.; A. 6 S., 17 R. Mottlings quite green. The crappie is decidedly humped on the back of the head or neck. Fins, D. 6 S., 15 R; A. 6 S., 17 R. Mottlings dark green. While the other may have seven spines in the dorsal, the crappie rarely if ever has so many. No finer pan fish swims, according to the writer's taste.

In the unequal-finned division there are, first, those with the *tongue toothless* and the body very short and deep. These are the true inland sunfishes. (You recall that there is a large "stump-tailed" ocean fish with that name also.) They are all fine biters and good to eat, though tedious to catch and clean. The author has caught them in the lakes of the plains at the rate of one a minute.

Among those with body short and *teeth on the tongue* are found the red-eyed breams or goggle-eyes. One has fins thus: D. 11 S., 10 R.; A. 6 S., 10 R. It is often called the rock-bass. The other, which is

FIG. 112.—Big-mouthed black bass (*Micropterus salmoides*), upper figure. Little-mouthed black bass (*Micropterus dolomiei*), lower figure.

the red-eyed bream proper, usually has only *three* spines in the anal and nine rays. The European bream belongs to a different family.

Among those with short bodies and *no* teeth on the tongue there are such common and important kinds as (1) have the fins *red or orange somewhere*, as the green sunfish. It has body green and brassy; blue spot on scales, with the edges of scales golden; fins blue and orange.

The long-eared sunfish is yellowish-green; spots on scales blue; head in front of eye striped with bluish; lower fins with much red. The common sunfish is also yellowish-green, with the sides largely mottled with blue; lower fins almost entirely orange; dorsal blue, with orange spots.

(2) The kinds without red on fins: The blue sunfish has no red on the fins; the spines are very high; grown fishes not spotted or marked; color, pale yellowish-green, darker in places.

In all those already noted the body is nearly half as deep as it is long. In the black basses the depth is only about one third of the length. In the others the dorsal fin is rather straight on the top edge, but in the basses it is very noticeably notched between the spines and soft rays. Fins, D. 10 S., 13 R.; A. 3 S., 10 R. (see Fig. 112).

In the large-mouthed black bass the mouth is very large; there are apt to be eleven soft rays in the anal fin, and it is said that "the ninth spine of the dorsal is *not* half so long as the longest spine."

In the small-mouthed black bass there are apt to

be only ten soft rays in the anal, the mouth is very small, and the ninth spine of dorsal is half as long as the longest. To the angler who has seen both, the open mouth distinguishes them at a glance.

No gamier fish abides than these black basses, being the people's fishes that come to them in what are almost domestic waters, making a line spin and a pole hum, and provoking all the cunning and skill of the most experienced angler. The small-mouthed is rather the favorite.

16. PERCHES (proper) (*Percidæ*).—Body longer and slimmer than in sunfishes—in fact, rather round; the gill-cover ends in a sort of spine, instead of a soft, membranous flap, as in the sunfishes; dorsal fin, separated; spines of first part, from six to fifteen; anal spines one or two, never three; ventrals (placed under pectorals) have one spine and five rays.

A large part of the family in the United States is made up of the darters—little things, never more than four inches long, sometimes only an inch and a half. They may be distinguished from the other little fishes, such as minnows, chubs, shiners, etc. (except sticklebacks), by having spines in the vertical fins, and from the sticklebacks by having no *free* spines (i. e., not connected with the rest of the fin).

These darters are distinguished from all other perches by *not* having the bone on the gill-cover strongly saw-toothed on its rear edge.

In the larger and more important perches this bone is strongly saw-toothed. They are:

(1) The common yellow perch: D. 13 S.—1 S.,

14 R.; A. 2 S., 7 R.; body rather oblong; golden-yellow, banded with dark rings.

FIG. 113.—White perch (*Roccus Americanus*), upper figure. Yellow perch (*Perca Americana*), lower figure.

(2) The pike-perch or wall-eyed pike (so called): D. 13 S.—1 S., 21 R.; A. 2 S., 12 R.; body long, slimmer, pikelike; greenish-yellow, mottled with brassy places; the fins and tail mottled. It is sometimes called "jack-salmon" in the Southwest.

(3) The sand-pike or sauger: D. 13 S.—1 S., 18 R.; A. 25—12 R.; body long, salmonlike, gray, with

dark blotches; a large rough-edged spot on the part of pectorals next the body.

None of these fishes is near akin to either salmons or pikes.

17. THE SEA-BASSES (*Serranidæ*).—Body long; mouth large; teeth on front part of the roof of the mouth; gill-cover armed with spines—the bone on it saw-toothed; spines in anals of one species three; anal quite short in extent along the body.

There is first a group in which the dorsal fin is deeply notched. In the "white-perch" and "yellow-perch" (so called) the parts are entirely separated. The white-bass has the teeth on the base of the tongue in *one* patch; body silvery-green above, striped *faintly* with darker: D. 9 S.—1 S., 14 R.; A. 3, S.—12 R.

The yellow-bass has the teeth same as the last; body more or quite brassy with seven very *plain black* stripes.

The so-called "white-perch" has a similar arrangement of the teeth, but sides silvery; not marked. Fin in this and the last: D. 9 S.—1 S., 12 R.; A. 3 S., 9 R.

The celebrated striped-bass has the teeth on the rear part of the tongue in *two* patches; body greenish-silvery, with about eight very distinct black stripes. It may be known from the yellow-bass, which is likewise beautifully striped, by noticing that in the former the parts of the dorsal fin are entirely separate, while in the latter the parts are evidently joined at the base.

In the black sea-bass the dorsal fin is all in one piece, no spine appearing in second part; the spines have threadlike ends running from them; body dusky and mottled; white spots on dorsal: D. 10 S., 11 R.; A. 3 S, 7 R.

18. SNAPPERS AND PORGIES (*Sparidæ*).—Body oblong, much elevated and thickened forward, making the fish appear hump-shouldered; lateral line present, unbroken; bone on gill-cover often toothed; anal spines 3; dorsal spines 8 to 13. Air-bladder present; one species with a crest or ridge on the head.

(1) Some have teeth on the front part of the roof of the mouth. Among these are the snappers and the rudder-fish. The former have some red about them. The gray snapper is mostly green, with red below only, and the anal fin round on edge; the red snapper is mostly red with anal fin pointed and projecting near the middle. The rudder-fish has no red about it. It has D. 12 S., 12 R.; while the others each have D. 10 S., 14 R.

(2) All the rest have no teeth on front roof of mouth; no red. The pigfish has the bone on gill-cover saw-toothed; sides gray, streaked with a series of yellow spots. D. 12 S., 16 R.

The penfish or bream (*Lagodon Rhomboides* of Linnæus—so many fishes are called breams) is silvery with the sides striped with blue and yellow or golden, and barred faintly with six blackish bands: D. 12 S., 11 R.

The sheepshead is plain gray, with seven *very*

black and quite broad bars (crosswise) (D. 12 S., 11 R.) also, but no yellowish or golden.

The porgy is gray, with purplish places, the sides silvery; no markings except in very young: D. 12 S., 12 R.

19. DRUMS, WEAKFISHES, ETC. (*Sciænidæ*).—Body stout, rather long and ordinary; head scaly; lateral line running clear out on tail-fin; dorsal almost cut in two; the soft rear part with twenty to thirty rays; not more than two spines in anal fin; dorsal spines nine or ten, the fin quite divided.

The white weakfish and the silver whiting are silvery without spots, streaks, or bars; snouts short and blunt. The first has the anal 2 S., 9 R.; the second A. 1 S., 9 R.; snout sticking far out.

All the rest of the family are dotted or streaked in some way. The weakfish proper has the body brownish, with wavy streaks of separate spots; fins *not* spotted; no scales on soft parts of dorsal and anal. The spotted weakfish is dark and silver with many plain spots on back and back fins: A. 1 S., 10 R. The yellow-tail is a silver color slightly tinged with greenish, having many fine points or dots on the body and fins. The lower fins are yellow as well as the tail: A. 2 S., 9 R. The so-called "channel bass" (*Sciæna ocellata*) is a silvery gray with wavy *brown* streaks; yellow and black on tail. When this fish (which may grow to four feet) is the size of the last (which is grown at nine inches) it has saw-teeth on the bone attached to the gill-cover, while the other never has. The "spot" of this same genus is a small

fish known by its bluish color and fifteen bars that run over it obliquely. The croaker is grayish silvery with wavy streaks on sides, but it is distinguished from the weakfish by having barbels on the lower jaw.

The whiting and barb are marked with oblique bands or bars, but are distinguished from the "spot" by having a single stout barbel on lower jaw: Anal 1 S., 7 or 8 R. The whiting has no black on the lower lobe or tail-fin while the barb has. This last has a great black blotch on the back of the neck shaped like a barb. It is dusky gray with distinct oblique bars. The whiting is lighter gray with very *faint* oblique bars.

All these others have had fine sharp teeth; but the drums have coarse blunt teeth set like stones in a pavement. The great ocean-drum is four feet long at its best, and has many barbels on the lower jaw. The fresh-water drum—with numerous other names (sheepshead, white perch, etc.)—has no barbels; it is two feet long. The teeth distinguish all of them without the aid of color.

20. HADDOCK OR ROSEFISH (*Scorpænidæ*).—Head with spiny ridges; spiny points or warts on gill-cover; dorsal unbroken, with fourteen spines; sides and top of head scaly (see Fig. 39, page 81).

We have only one of these in our waters. It is orange-red, with some dark about the gills. Sometimes they are found brown, but never with any markings or silvery whitish, as in sea-basses, etc.

21. SCULPINS (*Cottidæ*).—Body never wholly scaly, sometimes naked and warty; anal sometimes without spines (usual anal has one spine when dorsals are spiny). Pectorals broad, high on sides; ventrals low—on the throat—narrow (see Fig. 46, page 104).

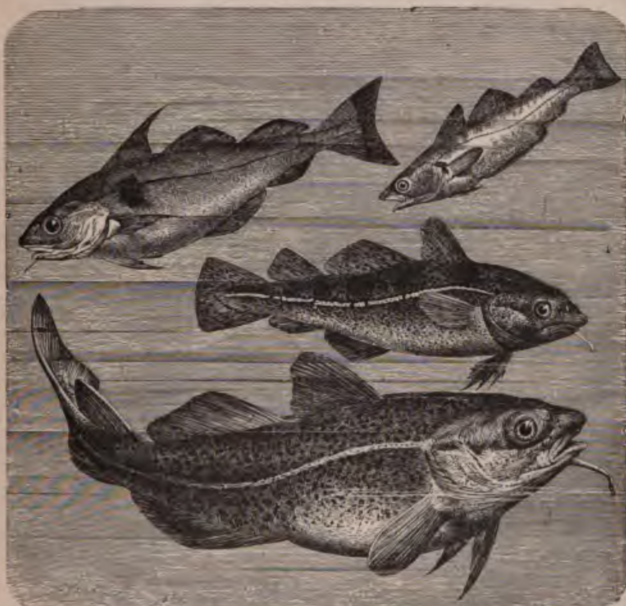

FIG. 114.—Haddock (*Metanogrammus ægelfinus*), upper figure on right. Whiting (*Merangus vulgaris*), upper figure on left. Cod (*Gadus morrhua*), two lower figures.

The important species are the sea-raven and the sculpin. Each has top of head rough or ridgy. The first is brown, blotched, and waved with black. Dorsal of 16 S., 13 R., very long. The sculpin is brown with

dark *bars*, the fins marked with black: D. 10 S., 17 R. One spine and three rays in ventral.*

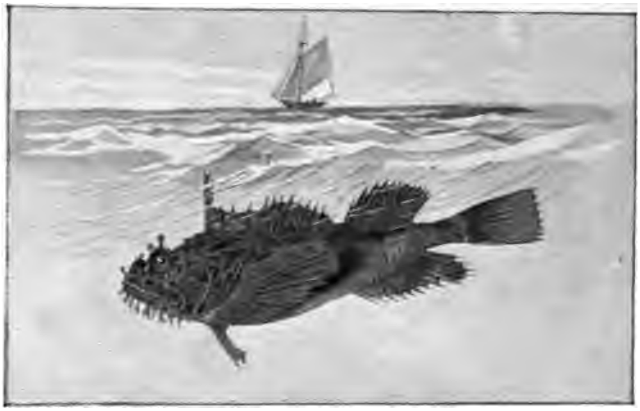

FIG. 115.—Sea-raven or deep-sea sculpin (*Hemitripterus hispidus*).

22. CODFISH, HAKES, ETC. (*Gadidæ*).—Body long; vertical fins very extensive, with *no spines*, and separated once, sometimes twice; chin with barbels in all genera except one; air-bladder present; scales small (see Fig. 114, page 279).

In the four-bearded rockling the dorsal is divided, but the first part has only one ray in front, somewhat like a spine in shape; but the rest of this part is a mere fringe, with no rays apparent.

All the other fishes have very apparent rays in the first part of the dorsal. In the cusk the dorsal is

* The flying gurnard (*Cephalacanthus volitans*), the plain gurnards (*Prionotus*), and the sculpin (*Hemitripterus americanus*) are often called "flying-fish," but only the first can fly imperfectly.

single, D. 98 R.—A. 71. In the codlings or hakes, and in the ling, the dorsal is in *two parts.*

The squirrel-hake and white hake have filaments of rays extending beyond the dorsal fin. Both have a barbel on chin, and not more than *three faint rays in the ventral fins*, but the former is inclined to be finely dotted on rather large scales, the latter plain with small unmarked scales. Fins of either, D. 9 R.—57 R.; A. 48 to 50. Anal undivided, of course.

In the ling or burbot there are *more than three rays in the ventral* fins. Vertical fins, D. 13 R.—76 R.; A. 68 R.

In all the foregoing with dorsal in two parts the lower jaw does not project, and it has a barbel on it. But in the silver-hake or "whiting" (so called) the lower jaw is longer than the upper, and there is no barbel on the chin: D. 13 R.—41 R.; A. 40 R.

All the rest of the important cod-forms have the *dorsal fin in three parts* and the *anal fins in two.* In these the pollock only has the lower jaw the longest, the barbel faint: D. 13 R.—22 R.—20 R.; A. 25 R.—20 R. In the true cod, the tomcod, and haddock, the upper jaw is longest. The haddock has the front part of the dorsal high and sharp-pointed, the edge incurved (concave), while in the true codfish it is not pointed and the edge is rounded outward (convex). In the tomcod the body is dotted with fine points, while in the others the markings are large. None of the cods are brilliant or strongly marked; the general color is brown with dark mottlings or blotches. This is a well-known family of food fishes, the dried and

salted codfish making nearly every small store, the country over, smell as if it were a hide-house.

23. FLATFISHES (*Pleuronectidæ*).—Body oblong, flattened; one side colored, other not; both eyes on upper side, as fish swims or rests; the vertical fins long, forming a sort of fringe nearly all around the body. Unlike as the two families may appear, their internal structure shows the flatfishes and the codfishes to be close akin (see Fig. 11, page 24).

The flounder-forms are distinguished by the edge of gill-cover being *not* covered by scales.

In some cases the lateral line is not distorted or arched up. This is so in the Greenland halibut and the winter flounder. In the former, besides its great size (often beyond four feet), the mouth is not much twisted, and the dorsal soft rays are about 100, the anal rays about 75. In the winter flounder the mouth is much twisted out of place and the fins are D. 65 R.—A. 48 R. In the others (of importance) the lateral line is distorted, arched, or curved upward toward the back edge, especially in front. In the great halibut (not the Greenland) and in the rusty dab the eyes are on the right side. In the former the mouth is not twisted much. The fins: D. about 100 R.; A. about 80 R.; length often six feet. In the dab the mouth is much twisted or out of place; size, about two feet; D. about 85 R.; A. about 60 R.

In the so-called summer flounders the eyes are on the *left side.* The four-spotted flounder has four large, *very plain*, dark spots with the edges pinkish. The summer flounder proper has some markings and

similar large spots *faintly* indicated. The southern flounder is a dark yellowish green, with almost no markings at all.

FIG. 116.—Frogfish or angler (*Lophius piscatorius*).

Our only sole has the gill-cover scaled so as to hide the edge of it, and is thus distinguished from flounders. It has no pectoral fins worth noting, and the ventrals are so merged into the anal as not to be easily distinguished. The curious little tongue-fish has the ventral of the upper side only present and separate.

Of course, such curious fishes as the (24) REMORAS (see Fig. 60, page 189), the (25) FROGFISH-FORMS, ETC.,

FIG. 117.—Toadfish (*Batrachus tau*).

are known by their sucking disks on the head, the gills behind the pectorals, etc.

Here follows a little key that in the most artificial way leads to the families just described.

KEY TO THE FAMILIES OF FAMILIAR FISHES.

If the character which is peculiar to your fish is not found at one letter, go on to the place where the letter is doubled, and you will find the opposite characters affirmed. Then turn back to the number to which you are finally led, and under the family the species will be found described, if it be a fish of much importance.

A. Eyes both on the same side; body flat, fringed nearly all around with fin-rays; one side colored, other nearly white; fish lies and swims on side. (This is one of the)

FLATFISHES (23).

AA. Eyes not both on same side.

B. Top of head with flat place—a sucking disk. (This is, etc.)

SUCKING-FISHES (24).

BB. Top of head without sucking disk.

C. Gill-openings behind pectoral fins; these fins shaped as if they had stems.

FROGFISHES (25).

CC. Gill-openings in front of ordinary pectorals. (This includes many fishes of the usual kinds.)

D. Body long and snakelike; no ventral fins. (It is one of the)

EELS (10).

DD. Body not snakelike; ventrals present.

E. Five rows of bony plates on body; on back a row of finlets; snout long and toothless; skeleton gristly.

STURGEON (1).

EE. Not five rows of plates; body scaly or naked.
F. Body naked and smooth; head flat, blunt—quite wide; mouth very wide—barbels about it.
CATFISHES (2).
FF. Body not naked, but always wholly or partly scaly.

(I) *No Spines in the Fins.*

(If there are spines, go on to II.)

G. Ventrals well forward, under or in front of the pectorals; Dorsal fins very long, or in two or more parts.
CODFISHES (22).
GG. Ventrals not under or front of pectorals; usually well toward the rear.
H. A single fat- (or rayless) fin near the tail on the back.
SALMONS (7).
HH. No fat-fins anywhere.
J. A bony plate under the lower jaw; scales very brilliant.
TARPUMS (5).
JJ. No bony plate under jaw.
K. Lateral line none; belly usually sharp and saw-toothed; mouth almost or wholly toothless.
HERRINGS (6).
KK. Lateral line present, wholly or in part.
L. Lateral line very plain; belly with sharp ridge; teeth on the tongue.
MOON-EYES (4).
LL. Lateral line faint or broken or extending only part of the way along the body.
M. Body rather oblong; mouth small; *no teeth on jaws.*
SUCKERS (3).
MM. Body slim; mouth large; large teeth everywhere.
PIKES (9).

(II) *Spines always present in Fins.*

N. Lateral line absent; four spines in dorsal.
MULLETS (11).

NN. Lateral line present and—
O. Running out on tail-fin rays.
DRUMS (19).

OO. Not running out on tail-fin.
P. Body never wholly scaly; sometimes warty.
SCULPINS (21).

PP. Body always wholly scaly.
Q. At least five finlets on tail-stem above and below, behind other vertical fins; jaws not beak-shaped.
MACKERELS (12).

QQ. Not five finlets anywhere.
R. Spines in front edge of anal fin *never* more than two; sometimes none.
(If more than two, go on to RR.)
S. Soft rays in the anal fin *never* more than twenty.
PERCHES (16).

SS. Soft rays of anal fin *always* more than twenty.
T. Teeth all weak and small.
POMPANOS (13).

TT. Teeth unequal, many of them large and set backward.
BLUEFISH (14).

RR. Spines in front edge of anal *always more than two.*
U. Gill-cover armed with spines either on the edge or surface.
V. Body red or brown, unmarked; spines on *surface* of gill-cover.
HADDOCK (20).

VV. Body never brown or red, either silvery or striped; flat spines on *edge* of gill-cover.
SEA-BASSES (17).

UU. Gill-cover not armed or spiny, but—
W. Round and hard on rear edge.
SNAPPERS (18).
WW. Not round but angled on rear edge, with a membranous flap or extension at the bend.
Common SUNFISHES (15).

INDEX.

THE END.